School of Engineering

HDR Project List

Geelong Waurn Ponds Campus

Deakin's School of Engineering is a leader in a number of engineering-focused research areas. We're committed to generating fundamental knowledge creation. We provide the highest-quality research training, state-of-the-art facilities and industry connections that make a real difference.

Need a supervisor? Explore the project list to connect with academics across our research themes additive manufacturing, civil engineering, design technology, electrical and electronics engineering, environmental engineering, mechanical and mechatronics engineering and renewable energy engineering.

Project list

Design, Simulation and 3D Printing of Y-Shape Nitinol Stents using SLM Technology

Abstract: The evolution of additive manufacturing technologies, particularly Selective Laser Melting (SLM), is significantly contributing to the modernisation of healthcare strategies. This research project intends to utilise these technologies to innovate within the realm of medical device manufacturing, specifically through the creation of personalised stents. The principal objective of this project is to design, simulate, construct, and evaluate a Y-shape stent made from Nitinol, a nickel-titanium alloy, using SLM 3D printing technology. Known for its unique shape memory and superelastic attributes, Nitinol provides a robust and adaptable material choice for stents, particularly those intended for deployment within bifurcating vessels. The study will require a comprehensive examination of the biomechanics associated with stent design, an in-depth understanding of Nitinol's material properties, and thorough knowledge of SLM 3D printer calibration and operation. With the successful realisation of these elements, the project aims to offer significant improvements in patient treatment plans. The project also holds substantial commercialisation potential, given the increasing demand for personalised healthcare solutions and more efficient treatment strategies in the medical industry. This study, therefore, represents a crucial step towards the further advancement of personalised healthcare in Australia and worldwide.

References:

Yan, Lina, et al. "Evaluation and characterization of nitinol stents produced by selective laser melting with various process parameters." Progress in Additive Manufacturing (2022): 1-13.

Farber, Eduard, et al. "A review of NiTi shape memory alloy as a smart material produced by additive manufacturing." Materials Today: Proceedings 30 (2020): 761-767.

Alipour, Saeid, et al. "Nitinol: From historical milestones to functional properties and biomedical applications." Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine 236.11 (2022): 1595-1612.

Key words: Selective Laser Melting (SLM), Nitinol Stents, Personalised Healthcare

Principal Supervisor:	Dr Saleh Gharaie
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School	School of Engineering
Course	S915 – Doctor of Philosophy (Engineering)
Campus	Geelong Waurn Ponds
Impact Theme	Improving health and wellbeing
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More information	Contact sebe-hdr-admissions@deakin.edu.au

Development and Performance Evaluation of a Novel Transcatheter Mitral Valve using 3D Printing Technology

Abstract: This research project focuses on the novel development and performance evaluation of a transcatheter mitral valve using advanced 3D printing technology. In the quest for improved patient outcomes and minimally invasive procedures, transcatheter mitral valves represent a significant evolution in cardiovascular medicine. The project aims to utilise a biocompatible silicone material, revered for its superior flexibility, in the fabrication of a customised and optimised prosthetic valve design. Following the fabrication, the valve will be subjected to rigorous performance evaluation, which includes in vitro testing under physiological conditions mimicked by a pulsatile flow system. Key performance indicators, such as pressure drop, regurgitant fraction, and effective orifice area, will be assessed, alongside an analysis of the valve's durability and fatigue resistance through cyclic testing. The outcome of this research could pave the way for advancements in the development and application of prosthetic mitral valves, moving closer to a future where patient-specific treatment is the norm.

References:

Singh, S. K., Kachel, M., Castillero, E., Xue, Y., Kalfa, D., Ferrari, G., & George, I. (2023). Polymeric prosthetic heart valves: A review of current technologies and future directions. Frontiers in Cardiovascular Medicine, 10, 1137827.

Key words: Transcatheter Mitral Valve, 3D Printing Technology and Prosthetic Valve Performance Evaluation

Principal Supervisor:	Dr Saleh Gharaie
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School	School of Engineering
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Influence of Plaque Composition on Haemodynamics and Rupture Risk: A Computational Study

Abstract: This research project seeks to elucidate the intricate link between plaque composition, coronary hemodynamics, and associated risks of plaque rupture. Using Computational Fluid Dynamics (CFD) simulations, the study models a variety of plaque compositions, exploring their impacts on key hemodynamic parameters, including pressure, velocity, and notably, wall shear stress—a potential biomarker for plaque stability. The simulations will account for the complex non-Newtonian behaviour of blood and the pulsatile nature of its flow. By offering a comprehensive understanding of the role plaque composition plays in influencing hemodynamics and rupture risks, this research is poised to significantly enhance the current knowledge of cardiovascular disease progression and guide the development of more effective, targeted treatment strategies.

References:

Yang, S., Koo, B. K., & Narula, J. (2022). Interactions between morphological plaque characteristics and coronary physiology: from pathophysiological basis to clinical implications. Cardiovascular Imaging, 15(6), 1139-1151.

Ebrahimi, S., & Fallah, F. (2022). Investigation of coronary artery tortuosity with atherosclerosis: A study on predicting plaque rupture and progression. International Journal of Mechanical Sciences, 223, 107295

Key words: Computational Fluid Dynamics (CFD),Atherosclerotic Plaque Composition,Coronary Haemodynamics

Principal Supervisor:	Dr Saleh Gharaie
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Performance Analysis and Optimisation of Next-generation Bioresorbable Stents Using Computational Fluid Dynamics and In Vitro Testing

Abstract: This research focuses on the performance analysis and optimisation of next-generation bioresorbable stents, leveraging Computational Fluid Dynamics (CFD) and in vitro testing methodologies. Bioresorbable stents represent a significant advancement in interventional cardiology, providing a temporary scaffold that gradually dissolves to minimise late-stage complications associated with permanent stents. A central challenge lies in predicting and optimising their interaction with blood flow and the subsequent dissolution process. This project combines CFD for performance prediction and in-depth analysis of hemodynamics with in vitro testing to validate computational results. The objective is to gain critical insights that will inform the improvement and optimisation of bioresorbable stent design and application.

References:

Li, Y., Wang, Y., Shen, Z., Miao, F., Wang, J., Sun, Y., ... & Guan, S. (2022). A biodegradable magnesium alloy vascular stent structure: Design, optimisation and evaluation. Acta Biomaterialia, 142, 402-412.

Key words: Bioresorbable Stents, Computational Fluid Dynamics (CFD), Haemodynamics and Stent Design Optimisation

Principal Supervisor:	Dr Saleh Gharaie
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Advancing Cardiac Care: A Novel Integration of Computational Fluid Dynamics and Artificial Intelligence for Early Intervention in Coronary Arteries

Abstract: Cardiovascular diseases remain a leading cause of mortality globally, with coronary artery disease (CAD) particularly prevalent. Traditional diagnostic methods often fall short in early detection and risk stratification, necessitating innovative approaches for timely intervention. This project aims to revolutionise cardiac care by integrating Computational Fluid Dynamics (CFD) and Artificial Intelligence (AI) to create a comprehensive diagnostic and predictive tool for CAD. Utilising CFD, the research simulates blood flow dynamics in coronary arteries to identify regions of disturbed flow and elevated wall shear stress, which are precursors to atherosclerotic plaque formation. Concurrently, machine learning algorithms are trained on a rich dataset comprising clinical, imaging, and haemodynamic parameters to predict the likelihood of plaque rupture and consequent cardiac events. The AI model also offers personalised treatment recommendations, such as stent placement or medication adjustments. The integration of these two advanced technologies aims to provide clinicians with a robust, real-time decision-making tool that enhances early intervention strategies. By achieving early and accurate diagnosis, the project aspires to reduce the incidence of acute cardiac events, improve patient outcomes, and ultimately transform the landscape of cardiac care.

References:

Candreva, A., De Nisco, G., Rizzini, M. L., D'Ascenzo, F., De Ferrari, G. M., Gallo, D., ... & Chiastra, C. (2022). Current and future applications of computational fluid dynamics in coronary artery disease. Reviews in Cardiovascular Medicine, 23(11), 377.

Chen, L., Park, C., Lin, A., Xing, E., Bano, R., Weber, J., ... & Cao, J. (2023). Artificial Intelligence Enabled Coronary Plaque Analysis Predicts Future Acute Coronary Syndrome: A Case-control Study. Journal of Cardiovascular Computed Tomography, 17(4), S42-S43.

Key words: Computational Fluid Dynamics (CFD), Artificial Intelligence, Coronary Artery Disease and Haemodynamic Parameters

Principal Supervisor:	Dr Saleh Gharaie
Associate Supervisor:	Dr Wei Luo
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Novel methods for evaluating and controlling fine particle fluidisation and cohesion through combined numerical model and experimentation

Abstract: Fine particle fluidisation is a core process in multiple industrial applications, including such diverse aspects as our work on the aerosolization of medicines in nasal and pulmonary inhalers, and the post-process de-powdering of additive manufacturing components from metal or polymer powder beds. These processes are notoriously challenging to control and to optimise in industry, and behaviour of fine powder dynamics involved have eluded our ability to robustly computationally model. As Gelhardt observed (1), such challenges can be ascribed to a complexity of powders that simultaneously behave as gases, liquids and solids. In recent studies, we have begun to appreciate new potential opportunities offered at the interface of well controlled experiments coupled with suitable computational approximations, including those offered by scaling from fine powder to granular dimensions, and from coupling of DEM and CFD models. This project will extend our current unpublished ongoing industry work, progressing these studies in revealing new ways to more closely model and predict such core applied processes. In particular it will explore the measuring and modelling of powder fluidisation (2), which we hypothesise could lead to uniquely sensitive and fundamental new rapid methodologies for measuring cohesion character within powder beds.

References:

Suhaidi, D, Dong, Y, Wynne, P. Hapgood, K & Morton D, (2023) "Bulk Flow Optimisation of Amorphous Solid Dispersion Excipient Powders through Surface Modification", Pharmaceutics 15(5), 1447.

Shekhar, S, Amini, N, Morton, D, Hapgood, K & Russell, A (2022), Highlighting DEM's Potential to Gauge Mechanistic Attributes of MUPS Tablet and Capsule Formulations, AAPS PharmSciTech 22(8), 1-7.

Antic, A, Zhang, J. Amini, N, Morton, D & Hapgood, K (2021), "Screening pharmaceutical excipient powders for use in commercial 3D binder jetting printers", Advanced Powder Technology, 32(7), 2469-2483.

Morton, D, (2017), "Dry powder inhaler formulations comprising surface-modified particles with anti-adherent additives", US Patent 9,585,834.

Tan, G, Morton, D & Larson, I, (2015) "On the methods to measure powder flow", Current Pharmaceutical Design, 21(40), p 5751-5765.

Key words: Powder Technology, Cohesion Measurement, Additive Manufacturing, Fluidisation and Pharmaceuticals

Principal Supervisor:	Prof David Morton
Associate Supervisor:	Dr Nhu Nguyen
School	School of Engineering
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Campus	Geelong Waurn Ponds
Impact Theme	Creating smarter technologies
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Assessing hardwood to softwood interface for cross-laminated timber

Abstract: Softwood is usually used for engineered timber products, such as cross-laminated timber (CLT). In Australia, Radiata Pine is widely used for mass engineered products. However, Australia has significant amount of hardwood population. This project aims to use hardwood for CLT. However, there are several challenges associated with using hardwood, such as, delamination. This project aims to evaluate the bond properties of hardwood.

References:

Li, X., Ashraf, M., Kafle, B., & Subhani, M. (2023). Effect of Fibre Orientation on the Bond Properties of Softwood and Hardwood Interfaces. Buildings, 13(4), 1011

Key words: Timber, Softwood, Hardwood, Interface and Cross-laminated timber

Principal Supervisor:	Dr Mahbube Sabhani
Associate Supervisor:	Dr Kazem Ghabraie
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Course	S915 – Doctor of Philosophy (Engineering)
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Next generation sustainable hybrid products

Abstract: The proposed study aims to develop hybrid thin-walled structures using locally sourced wood and basalt fibre-reinforced polymers (BFRP) to provide high-performing sustainable materials in construction and transportation compared to typical metallic or concrete counterparts. Veneers of both low- and high-grade timber will be used in hybrid structural panels with local reinforcements of BFRP. The combination of three material systems will be optimised such a way that various desired mechanical and fracture properties can be achieved to use for automobile and construction applications.

References:

Reiner, J., Pizarro, S. O., Hadi, K., Narain, D., Zhang, P., Jennings, M., & Subhani, M. (2023). Damage resistance and open-hole strength of thin veneer laminates: Adopting design and testing principles from fibre-reinforced polymers. Engineering Failure Analysis, 143, 106880.

Key words: Veneer, Timber, Basalt fibre-reinforced polymers (BFRP), Hybrid and sustainable

Principal Supervisor:	Dr Mahbube Sabhani
Associate Supervisor:	Dr Johannes Reiner
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Development of Basalt Fibre Reinforced Polymer (BFRP) Rebar Infused with Geopolymer Binder

Abstract: Due to the non-corrosive nature and high tensile strength, various types of fibre reinforced polymer (FRP) rebar are increasingly used in concrete structures targeting a longer service life with reduced maintenance cost. Even though FRP rebars possess numerous advantages over conventional steel rebars, the modulus of elasticity and bond strength of FRP rebars are significantly lower than that of the steel rebars, because these properties are mainly controlled by the properties of the resin system used to impregnate the fibres. Moreover, the nature of non-compatibility between inorganic concrete and organic polymer from FRP leads to poor interfacial bonding. Also, the failure of FRP rebar in a brittle manner limits its application in concrete structures subjected to lateral loads. These shortcomings of FRP rebars limit their use in some concrete structures. This study will develop basalt FRP (BFRP) rebars by impregnating BFRP fibre with a hybrid binder made of geopolymer and epoxy resin and investigated its mechanical properties.

References:

Subhani, M., Shill, S. K., Garcez, E., Varley, R., & Gan, J. (2023). Development of Basalt Fibre Reinforced Polymer (BFRP) Rebar Infused with Geopolymer Binder. In International Symposium of the International Federation for Structural Concrete (pp. 599-608). Cham: Springer Nature Switzerland.

Key words: Geopolymer, Rebar, Basalt fibre-reinforced polymers (BFRP) Hybrid and Materials

Principal Supervisor:	Dr Mahbube Sabhani
Associate Supervisor:	Prof Russell Varley and Dr Jerry Gan
School	School of Engineering
Course	S915 – Doctor of Philosophy (Engineering)
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Structural optimisation and design and its applications

Abstract: This is a generic topic covering the broad areas of developing new approaches and algorithms, improving existing methods, exploring new problems and applications, etc.

References:

MP Bendsoe & O Sigmund (2003) Topology optimization: theory, methods, and applications, Springer. GIN Rozvany (2012) Structural design via optimality criteria: the Prager approach to structural optimization, Springer.

X Huang & YM Xie (2010) Evolutionary topology optimization of continuum structures: methods and applications, Wiley.

Key words: Structural optimisation, Lightweight structures, Topology optimisation, Shape optimisation and multi-objective optimisation

Principal Supervisor:	Dr Kazem Ghabraie
Associate Supervisor:	To be confirmed
School	School of Engineering
Course	S915 – Doctor of Philosophy (Engineering) S825 Master of Engineering (Research)
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More information	Contact sebe-hdr-admissions@deakin.edu.au

Applications of recycled thermoplastics in construction

Abstract: This project explores the potential applications of recycled thermoplastics in construction. The project could involve testing existing products or designing new products made of recycled plastics for applications in different construction sectors.

References:

ME Grigore (2017) Methods of recycling, properties and applications of recycled thermoplastic polymers. Recycling, 2(4): 24.

JML Reis, LJ Pacheco & HS. da Costa Mattos (2013) Tensile behaviour of post-consumer recycled high-density polyethylene at different strain rates, Polymer Testing, 32(2): 338-342.

JP Manaia, FA Pires, AMP de Jesus & S Wu, (2019) Yield behaviour of high-density polyethylene: Experimental and numerical characterization, Engineering Failure Analysis, 97: 331-353.

Key words: Recycled plastics, Thermoplastics, Sustainable material and Sustainable construction

Principal Supervisor:	Dr Kazem Ghabraie
Associate Supervisor:	Dr Mahbube Subhani and/or Dr Omid Zabihi
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Connection designs in timber structures

Abstract: This is a broad topic looking at analysis, desing, and/or optimisation of different types of connections in timber structures, including adhesive and non-adhesive connections.

References:

LM Ottenhaus, R Jockwer, D van Drimmelen & K Crews (2021) Designing timber connections for ductility–A review and discussion. Construction and Building Materials, 304, 124621.

LM Ottenhaus, Z Yan, R Brandner, P Leardini, G Fink & R Jockwer (2023) Design for adaptability, disassembly and reuse–A review of reversible timber connection systems. Construction and Building Materials, 400, 132823.

T Vallée, T Tannert & S Fecht (2017) Adhesively bonded connections in the context of timber engineering–A Review. The Journal of Adhesion, 93(4), 257-287.

A Amirsardari, J Lee, E Gad & L Pham (2023) Review of timber connection design in Australia. Australian Journal of Structural Engineering, 1-11.

Key words: Timber structures, Timber engineering and Timber Connections

Principal Supervisor:	Dr Kazem Ghabraie
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An Integrated Approach for Smart Coordinated Control, Energy Management, and Inertial Support with Fast Frequency Response for FCAS.

Abstract: The Australian power systems are undergoing a rapid transformation, transitioning towards dynamic and intricate systems where wind, solar PV, and battery energy storage (BESS) are replacing conventional synchronous generators. This shift has introduced new challenges in maintaining frequency control for the stability and security of power systems, both during steady-state operations and transients. A significant challenge arising from this transformation is the increasing Rate of Change of Frequency (RoCoF), necessitating fast frequency control within a limited timeframe. This proposed project aims to devise an FCAS scheme for Fast Frequency Response (FFR) by enabling the inverter to operate in the grid-forming mode, supported by battery energy storage. Coordinated control systems will be developed for solar PV and BESS, serving the following main objectives: 1) Investigate the impact of low inertia on power grid stability with increased penetration of inverter-based renewable energy sources. 2) Develop a coordinated control algorithm to enable the inverter to function as a grid-forming inverter, providing inertia support and fast frequency response with the assistance of battery energy storage. 3) Create a smart energy management scheme (EMS) for the solar PV-based microgrid with battery storage, facilitating effective charging/discharging management and fulfilling system operation requirements for FFR.

Reference:

AEMO Inertia Report, 2022.

Key words: Energy management, Fast frequency response and Inertia

Principal Supervisor:	Dr Ameen Gargoom
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School	School of Engineering
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Advances in Grid-Forming Inverters for Power System Support

Abstract: As power systems evolve towards higher renewable energy penetration, the traditional grid-following inverters face limitations in maintaining grid stability and reliability. Grid-forming inverters offer a promising solution by actively regulating both voltage and frequency, enabling them to provide vital grid support services. However, there is a pressing need for sophisticated modelling and control approaches to harness the full potential of grid-forming inverters. This project will address this challenge by developing innovative modelling techniques that accurately capture the dynamic behaviour of grid-forming inverters under varying grid conditions. Moreover, advanced control strategies will be designed to ensure seamless integration of grid-forming inverters within the power system, enabling them to actively contribute to voltage and frequency control, power quality improvement, and enhanced grid resilience. The project's outcomes will facilitate the efficient deployment of grid-forming inverters and pave the way for a more reliable and sustainable power grid in the face of increasing renewable energy integration.

Reference:

Fazal, Sana, Md Enamul Haque, Mohammad Taufiqul Arif, Ameen Gargoom, and Aman Maung Than Oo. "Grid integration impacts and control strategies for renewable based microgrid." Sustainable Energy Technologies and Assessments 56 (2023): 103069.

Key words: Grid forming, Renewable energy and Grid support.

Principal Supervisor:	Dr Ameen Gargoom
Associate Supervisor:	A/Prof Md Enamul Haque and Dr Mohammad Taufiqul Arif
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Future Challenges in Distribution Networks with High Penetration of Electric Vehicles

Abstract: With the rapid growth of electric vehicle (EV) adoption, distribution networks will face new demands, both in terms of electricity supply and management. This project aims to analyse and address the challenges arising from the bi-directional power flow between the grid and EVs, considering grid to vehicle (G2V) charging, vehicle to grid (V2G) discharging, and other emerging applications such as vehicle-to-building (V2B) and vehicle to house (V2H) integration. The research will investigate advanced power management and control strategies to optimize the charging and discharging processes, taking into account the intermittent nature of renewable energy sources and the dynamic charging behaviours of EVs. Additionally, the project will explore the potential benefits and challenges associated with V2G services, such as grid support, demand response, and energy arbitrage, to ensure the optimal utilization of EV batteries while maintaining grid stability and reliability.

Reference:

Mastoi, Muhammad Shahid, Shengxian Zhuang, Hafiz Mudassir Munir, Malik Haris, Mannan Hassan, Mohammed Alqarni, and Basem Alamri. "A study of charging-dispatch strategies and vehicle-to-grid technologies for electric vehicles in distribution networks." Energy Reports 9 (2023): 1777-1806.

Key words: Electric vehicle, V2G, G2V, G2H.

Principal Supervisor:	Dr Ameen Gargoom
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Biochar-based solar evaporators for low-cost freshwater production

Abstract: Freshwater is a scare recourse in many countries including Australia. Most existing desalination technologies for freshwater production are based on reverse osmosis using membranes. They are energy intensive and costly to operate. The proposed PhD project aims to design and develop cost-effective solar-driven water evaporators enhanced by nanomaterials made from biosolids and biochar (by-products from wastewater treatment). Researchers in the Institute for Frontier Materials (IFM) at Deakin University has recently developed new nanomaterials using food waste. When coated on common porous materials, such as foams, the nanomaterials can significantly enhance the rate of water evaporation through increasing the effective surface area and enhancing the absorption of radiant energy. This creates an opportunity for developing low-cost solar-powered water evaporators for zero-carbon water treatment and freshwater production. This project may involve the following research objectives: (1) to investigate how biosolids and biochar can be best used to produce materials for solar energy absorption and water evaporation; (2) to design and fabricate a prototype solar evaporator using the nano materials for freshwater production from seawater; and (3) to optimise the design of the solar evaporator for large scale applications.

References:

Zhang, Q., Ye, Q., Zhang, Y., Cai, Q., Dang, Y., Pang, H., and Wu, X. (2022). "High efficiency solar interfacial evaporator for seawater desalination based on high porosity loofah sponge biochar." Solar Energy, 238, 305-314.

Wang, L., Ma, Y., Yang, G., Li, X., Liu, D., Qin, S., and Lei, W. (2023). "Asymmetric Solar Evaporator with Self-Cleaning Capability for Freshwater and Energy Generation." SSRN

Lim, H., and Kim, S. K. (2023). "An easily scalable, durable, and highly efficient three-dimensional solar evaporator inspired by a rice paddy field." Desalination, 548, 10.1016/j.desal.2022.116251.

Key words: Biochar, Desalination, Nanomaterials, Solar evaporators and Water treatment

Principal Supervisor:	Dr James Gong
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School	School of Engineering
Course	S915 – Doctor of Philosophy (Engineering)
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Leak detection for plastic water pipe networks

Abstract: The continuing economic success and social well-being of water-scarce countries such as Australia relies on a sustainable supply of potable water transmitted through extensive pipeline systems. Plastic pipes have been increasingly used to replace ageing metal pipes. However, there is no cost-effective solution to leak detection in plastic water pipes. Effective leak detection techniques that can be applied to large scale plastic pipe networks are needed for saving water, preventing pipe breaks, and enabling targeted pipe maintenance. This PhD project will use hydro-acoustic waves as a tool to assess the condition of plastic water pipes. New knowledge will be generated on how pressure waves propagate and reflect in plastic pipe networks, and new techniques will be developed to detect anomalies such as leaks. The candidate will receive excellent research training through conducting analytical analysis, numerical simulations and also laboratory experiments.

References:

Folkman, S. (2018). "Water main break rates in the USA and Canada: a comprehensive study." Utah State University, Logan, Utah, US.

Zeng, W., et al. (2021). "Extremely sensitive anomaly detection in pipe networks using a higher-order paired-impulse response function with a correlator." J. Water Resour. Plan. Manage., 147(10), 04021068.

Muggleton, J. M., and Rustighi, E. (2016). "A novel method for the remote condition assessment of buried pipelines using low-frequency axisymmetric waves." Journal of Physics: Conference Series, 744(1)

Key words: Acoustic, Transient, Water Distribution Systems and Water Hammer

Principal Supervisor:	Dr James Gong
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Impact Theme	Creating smarter technologies
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship
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Optimising the Design of Premise Water Supply Systems

Abstract: This PhD project aims to advance knowledge in the design of premise water supply systems and develop techniques and tools to improve the design approaches. Over the past few decades, water use habits have shifted and plumbing technologies have advanced significantly, while the design standards and practices have not kept pace with the changes. The focus of this project can be on one of the following areas: hydraulic performance (including steady and unsteady flows), energy efficiency and carbon emission, water quality and life cycle analysis. The development will be mainly based on numerical simulations, and laboratory experiments can be a complementary part. The project will enable an urgently needed update to the design approach of premise water supply systems, contributing to sustainable water supply in buildings.

References:

Persily, A., et al. (2020). "Measurement Science Research Needs for Premise Plumbing Systems." National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA.

Brendan, J. M., et al. (2023). "Comparing Actual and Designed Water Demand in Australian Multilevel Residential Buildings." J. Water Resour. Plan. Manage., 149(1), 05022013.

Arup Inc. (2023). "Energy and Water Savings Opportunities of the IAPMO Water Demand Calculator." International Association of Plumbing and Mechanical Officials (IAPMO), San Francisco, CA, USA.

Key words: Buildings, Climate Change, Green House Gas, Optimisation and Plumbing

Principal Supervisor:	Dr James Gong
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Impact Theme	Enabling a sustainable world
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
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Advanced hydrologic data completion methods for stream classification and modelling

Abstract: This PhD project aims at assessing advanced stochastic methods for data hydrologic data completion and the influence of using synthetic data on rainfall runoff modelling for stream classification. In many regions around the world, lack of good-quality and continuous hydrologic data records difficulties the implementation of modelling approaches commonly used for water management plans and policy making. Long term modelling is also used to analyse patterns of water permanence or perenniality of streams which leads to a better description of the environmental conditions of the streams. The project will focus on large scale data analysis, numerical simulations and generation of simulations tools that can be applied to a wide a range of catchments. Advanced regression and stochastic analysis using available machine learning libraries can provide a solution to lack of data by generation of synthetic data to complete timeseries, but questions surrounding the quality of synthetically generated data and its usefulness for modelling are yet to be assessed.

References:

Verdon-Kidd, Danielle C. and Sandi, Steven G. and Metcalfe, Angela G. and Kidd, Luke J., Challenges of Classifying and Mapping Perennial Freshwater Systems within Highly Variable Climate Zones: A Case Study in the Murray Darling Basin, Australia. (preprint), Link

Sandi, E.A.; Oreamuno-Vega, R. and Sandi, S.G. (2022) Simulating the Water Regime in the Abangares River Catchment, Costa Rica: Implications for Management and Planning, Proceedings of the 39th IAHR World Congress, Granada, Spain

Key words: Hydrologic modelling, Synthetic data, Catchment analysis and Perennial streams

Principal Supervisor:	Dr Steven Sandi Rojas
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Numerical approaches for simulation of carbon sequestration in mangroves

Abstract: This PhD project aims at the development of numerical simulation tools for coastal wetland vegetation dynamics that can account for sequestration of soil carbon in mangrove systems. Mangroves are among the most efficient systems for accumulating carbon, but at the same time a range of threats related to changes in land use, climate and water quality increase the vulnerability of these environments to continue providing ecosystem services in the long terms. Numerical simulations combining hydrodynamics, vegetation growth and establishment as well as sediment deposition can provide valuable insights into the future of mangroves. The project will focus on the development of numerical models and simulation of a diverse range of scenarios to test the vulnerability of mangrove systems. The project will help inform the implementation and design of wetland restoration and rehabilitation strategies with habitat provision and carbon sequestration and the main objectives.

References:

Sandi, S. G., Rodriguez, J. F., Saco, P. M., Saintilan, N., & Riccardi, G. (2021). Accelerated sea-level rise limits vegetation capacity to sequester soil carbon in coastal wetlands: A study case in southeastern Australia. Earth's Future, 9, Link

Breda, A., Saco, P. M., Sandi, S. G., Saintilan, N., Riccardi, G., & Rodríguez, J. F. (2021). Accretion, retreat and transgression of coastal wetlands experiencing sea-level rise. Hydrology and Earth System Sciences, 25(2), 769-786. ;

Key words: Soil carbon, Numerical modelling, Sea-level rise, Eco-hydrology and Mangroves	
Principal Supervisor:	Dr Steven Sandi Rojas
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Impact Theme	Enabling a sustainable world
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
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4D Printing of Medically Assisted Devices

Abstract: The field of 4D printing has emerged as a cutting-edge technology, enabling the design and fabrication of dynamically responsive structures that adapt to external stimuli. This transformative approach has shown great promise in revolutionizing medically assisted devices, including rehabilitative devices, surgical tools, stents, and beyond. However, to fully harness the potential of 4D printing in this domain, certain critical gaps need to be addressed. This proposed PhD project aims to explore and overcome the technical challenges hindering the widespread adoption of 4D printing for medically assisted devices. One key technical aspect will involve advancing the development of smart materials with precise and programmable response characteristics. The research will delve into the development of novel materials, such as shape-memory polymers, with a particular focus on achieving enhanced mechanical properties.

References:

Mohammadi, M., Zolfagharian, A., Bodaghi, M., Xiang, Y. and Kouzani, A.Z., 2022. 4D printing of soft orthoses for tremor suppression. Bio-Design and Manufacturing, 5(4), pp.786-807.

Mohammadi, M., Kouzani, A.Z., Bodaghi, M., Xiang, Y. and Zolfagharian, A., 2023. 3D-Printed Phase-Change Artificial Muscles with Autonomous Vibration Control. Advanced Materials Technologies, p.2300199.

Naniz, M.A., Askari, M., Zolfagharian, A., Naniz, M.A. and Bodaghi, M., 2022. 4D printing: A cutting-edge platform for biomedical applications. Biomedical Materials, 17(6), p.062001.

Zolfagharian, A., Khosravani, M.R., Duong Vu, H., Nguyen, M.K., Kouzani, A.Z. and Bodaghi, M., 2022. AI-based soft module for safe human–robot interaction towards 4D printing. Polymers, 14(16), p.3302.

Sahafnejad-Mohammadi, I., Karamimoghadam, M., Zolfagharian, A., Akrami, M. and Bodaghi, M., 2022. 4D printing technology in medical engineering: A narrative review. Journal of the Brazilian Society of Mechanical Sciences and Engineering, 44(6), p.233.

Key words: 3D printing, Advanced Manufacturing, Medical Device, Design and Soft Actuators

Principal Supervisor:	Dr Ali Zolfagharian
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Impact Theme	Creating smarter technologies
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
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Sustainable Robots Manufacturing

Abstract: Nature frequently inspires modern robotics innovations with a focus on secure human-machine interaction. However, integrating automation and digital technologies raises concerns about environmental sustainability. To address this, biodegradable soft robots have been proposed for intelligent applications, leveraging shape transformation in response to external stimuli. Conventional manufacturing techniques for soft robot fabrication are inflexible, time-consuming, and labour-intensive. Recent advances in 3D and 4D printing of soft materials offer a promising solution for direct and efficient manufacturing of complex soft robotics. This research aims to explore the potential of sustainable 4D printing techniques to create biodegradable soft sensors and actuators. By conducting a comprehensive survey of 3D and 4D printing advances in biodegradable soft sensors and actuators, as well as evaluating biodegradable materials for flexible devices with medical and industrial applications, this study will contribute to the development of eco-friendly and adaptable soft robotic systems aligned with global environmental objectives.

References:

Zolfagharian, A., Lakhi, M., Ranjbar, S., Tadesse, Y. and Bodaghi, M., 2022. 3D printing non-assembly compliant joints for soft robotics. Results in Engineering, 15, p.100558.

Zolfagharian, A., Bodaghi, M., Heidarian, P., Kouzani, A.Z. and Kaynak, A., 2022. Closed-loop control of 4D-printed hydrogel soft robots. In Smart Materials in Additive Manufacturing, Volume 2: 4D Printing Mechanics, Modeling, and Advanced Engineering Applications (pp. 251-278). Elsevier.

Zolfagharian, A., Kaynak, A. and Kouzani, A., 2020. Closed-loop 4D-printed soft robots. Materials & Design, 188, p.108411.

Key words: Sustainable, Robotic, Manufacturing, Sensors and Actuators

Principal Supervisor:	Dr Ali Zolfagharian
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Impact Theme	Enabling a sustainable world
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
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Reverse Design of Tuneable 4D Printed Materials for Soft Robotics

Abstract: This project aims to facilitate the design and manufacture of specialised objects that can change their shape over time. These types of objects are made from 'tuneable metamaterials', which can be made by 4D printing: 3D printing with an added dimension of time. These materials are becoming indispensable in many fields- including non-metallic soft robots used in medicine or the exploration of harsh environments like space- but are currently onerous to make. This project will develop a revolutionary new method for a user to work backward from defining the desired qualities to the manufacture of the object that satisfies their needs. It will also create a library that will allow users to quickly select a material that will be appropriate.

References:

Zolfagharian, A., Jarrah, H.R., Xavier, M.S., Rolfe, B. and Bodaghi, M., 2023. Multimaterial 4D printing with a tunable bending model. Smart Materials and Structures, 32(6), p.065001.

Zolfagharian, A., Kaynak, A. and Kouzani, A., 2020. Closed-loop 4D-printed soft robots. Materials & Design, 188, p.108411.

Zolfagharian, A., Bodaghi, M., Hamzehei, R., Parr, L., Fard, M. and Rolfe, B.F., 2022. 3D-printed programmable mechanical metamaterials for vibration isolation and buckling control. Sustainability, 14(11), p.6831.

Zolfagharian, A., Picken, P., Bodaghi, M., Fard, M. and Rolfe, B., Additive Manufacturing of Composite Foam Metamaterial Springs for Vibration Isolation. Advanced Engineering Materials.

Key words: 4D printing, soft robotics, design, smart materials and additvie manufacturing

Principal Supervisor:	Dr Ali Zolfagharian
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School	School of Engineering
Course	S915 – Doctor of Philosophy (Engineering)
Campus	Geelong Waurn Ponds
Impact Theme	Creating smarter technologies
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
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Vibration Isolation via 3D-Printed Metamaterials

Abstract: This PhD proposal presents an innovative approach to mitigate vibrations in mechanical devices and systems through the integration of metamaterials to enhance vibration isolation. The research explores the utilization of variable stiffness metamaterials to design compliant mechanisms with specific force-displacement regions aiming to achieve effective vibration isolation across diverse scenarios. The study utilizes additive manufacturing methods to develop customizable and scalable metamaterials. The investigation involves identifying geometric, material, and systemic design requirements to achieve desired force-displacement characteristics. Small-scale models of various devices are developed and subjected to rigorous static and dynamic testing. The outcomes of this research are expected to yield practical applications for implementing metamaterials in diverse devices and systems, improving vibration isolation under dynamic loading conditions, such as vehicles, robotic, etc. The proposed material library and design variables offer versatility and application-specific solutions, enabling tailored vibration control solutions to suit a wide range of engineering and industrial requirements.

References:

Lalegani Dezaki, M., Bodaghi, M., Serjouei, A. and Zolfagharian, A., 2023. Green 3D-printed lattice-shaped suspension arms for RC cars. Progress in Additive Manufacturing, pp.1-15.

Hamzehei, R., Zolfagharian, A., Dariushi, S. and Bodaghi, M., 2022. 3D-printed bio-inspired zero Poisson's ratio graded metamaterials with high energy absorption performance. Smart Materials and Structures, 31(3), p.035001.

Yousefi, A., Jolaiy, S., Lalegani Dezaki, M., Zolfagharian, A., Serjouei, A. and Bodaghi, M., 2023. 3D-Printed Soft and Hard Meta-Structures with Supreme Energy Absorption and Dissipation Capacities in Cyclic Loading Conditions. Advanced Engineering Materials, 25(4), p.2201189.

Key words: Vibration, Metamaterials, 3D Printing; Mechanical Tests and Compliant Mechanisms

Principal Supervisor:	Dr Ali Zolfagharian
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Campus	Geelong Waurn Ponds
Impact Theme	Creating smarter technologies
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship
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Hydrogen fuel cells in Australian truck fleet

Abstract: This project investigates the utilisation of hydrogen fuel cells in trucks on-road in Australia to decarbonise and reduce the amount of using fossil fuels in the transportation sector. The specific objectives of this project are:

• Performance characteristics of hydrogen fuel cell powered trucks as compared to battery electric, hybrid hydrogen fuel cell, and internal combustion engine trucks. The modelling study will be done in AVL software.

• Impact of Australian road and weather conditions on hydrogen fuel cell performance.

• Life-cycle analysis and economic feasibility of hydrogen fuel cells in Australian truck fleet.

• Feasibility of using hydrogen fuel cells in Australian truck fleet: Hydrogen fuel cell and Hybrid hydrogen fuel cell.

References:

Eyad Abouelkhair, Farhad Salek, Meisam Babaie, Comparative Energy Analysis of the Conventional and Fuel Cell Electric Powertrains for a Medium-Duty Truck, SAE International Journal of Electrified Vehicles, 12, 14-12-01-0004, p 45-61.

Key words: Hydrogen fuel cell truck, Vehicle performance characteristics and Electric vehicle,

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Impact Theme	Enabling a sustainable world
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship
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Optimising environmental monitoring for carbon sequestration site

Abstract: You will research in water, groundwater, and geo-sequestration of carbon. Research in this water-energy-waste nexus with storage of carbon underground will develop and deploy a multi-disciplinary (environmental engineering, soil gas chemistry and hydrogeology) approach at an exciting time of accelerating transitions to net-zero carbon emissions.

References:

Zhang K, Prof W. Timms, Dr S. Stevanovic, Dr W. Howcroft , S. H. Lim and P. Barraclough (2022). Groundwater and Soil Gas for Assurance Monitoring at CCUS sites. Abstract for Australasian Groundwater Conference, Perth, 21-23 November 2022.

Deslandes A, Axel Suckow, Punjehl Crane, Christoph Gerber, Cornelia Wilske, Dirk Mallants, William Howcroft, Wendy Timms, Svetlana Stevanovic (2022). Noble Gas Tracers for Geosequestration and Storage Projects. Abstract for Australasian Groundwater Conference, Perth, 21-23 November 2022.

Caritat, P. D., Hortle, A., Raistrick, M., Stalvies, C., & Jenkins, C. (2013). Monitoring groundwater flow and chemical and isotopic composition at a demonstration site for carbon dioxide storage in a depleted natural gas reservoir. Applied Geochemistry, 30, 16-32.

Romanak, K. D., & Bomse, D. S. (2020). Field assessment of sensor technology for environmental monitoring using a process-based soil gas method at geologic CO2 storage sites. International Journal of Greenhouse Gas Control, 96, 103003.

Key words: Carbon storage, Soil gas, Groundwater and Engineering

Principal Supervisor:	Prof Wendy Timms
Associate Supervisor:	Dr Svetlana Stevanovic
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Course	S915 – Doctor of Philosophy (Engineering)
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Impact Theme	Creating smarter technologies
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
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More information	Contact sebe-hdr-admissions@deakin.edu.au

Water storage and monitoring technologies for soils and underground systems

Abstract: This applied research would continue world-leading research on water storage and advanced monitoring technologies for soils and underground systems. This research includes developing improved instrumentation systems for subsurface and advanced analysis of pore pressure data and direct measurement of recharge drips. The high-frequency data collected by these sensors and instruments are then transformed with advanced analysis to provide information for decision makers in large engineering projects. For example, pore pressure responses to high frequency 'passive' loading by atmospheric and earth tides can be used to derive in situ hydro-geomechanical properties of soils, rock strata and groundwater systems. These advances are novel and could transform engineering practices for groundwater supply bores, and excavations for mining and tunnelling. Our current research to improve inputs to models of sustainable water, and to design more effective and safer underground systems for mines and tunnels. Current research in this area is support by industry partners in geotechnical/mining engineering, the Victorian government (sustainable water yields review) and an ARC infrastructure project with UNSW and Flinders University.

References:

Fang K, J Zhang, L Cui, L Ding, X Xu, W Timms (2023) Mathematical modelling and simulation for hydrating backfill body under cemented paste backfill/rock interface loading, International Journal of Mining, Reclamation and Environment 37 (2), 87-109

Rau GC, TC McMillan, MS Andersen, WA Timms (2022) In situ estimation of subsurface hydro-geomechanical properties using the groundwater response to semi-diurnal Earth and atmospheric tides, Hydrology and Earth System Sciences 26 (16), 4301-4321

Barzegar M, S Blanks, BA Sainsbury, W Timms (2022) MEMS technology and applications in geotechnical monitoring: a review, , Measurement Science and Technology 33 (5), 052001

Wang Y, ALZ Almutairi, P Bedrikovetsky, WA Timms, KL Privat (2022) In-situ fines migration and grains redistribution induced by mineral reactions–Implications for clogging during water injection in carbonate aquifers, Journal of Hydrology 614, 128533

Chowdhury F, J Gong, GC Rau, WA Timms (2022) Multifactor analysis of specific storage estimates and implications for transient groundwater modelling, Hydrogeology Journal 30 (7), 2183-2204

Key words: Water supply, Geotechnical engineering and Mining engineering	
Principal Supervisor:	Prof Wendy Timms
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Impact Theme	Creating smarter technologies
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
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Quantification of the mechanical strength of cemented paste tailings for mining

Abstract: Placement of cemented paste backfill (CPB) at many underground mines is discontinuous due to interruptions and delays in operational shift schedules, plant batching procedures and maintenance required on the reticulation system. This discontinuous filling can result in the formation of planes of weakness (discontinuities) between CPB pours which are referred to as 'cold joints', 'flow joints' or 'batch joints'. The frequency and size of discontinuities within the fill mass can be further increased during flushing of the reticulation system whereby water or low cement 'slick' products are flushed through the reticulation pipes and into the stopes. These discontinuities are sometimes referred to as 'slurry', 'slick' or 'water' joints. The presence of any of these discontinuities (cold, batch, flow, slick, slurry or water joints) within CPB are known to have an impact on the stability behaviour of underhand stope exposures (Li et al. 2014). They have previously been observed to be a contributor to an underhand backfill failure at the Lucky Friday Mine in 2014 (Johnson et al. 2015) and dilution at Henty Mine (Sainsbury and Cai 2001) and Fosterville Gold Mine (Farrington 2020). Although they are frequently observed during exposure (Figure 1) there is limited understanding of their mechanical properties and impact on design (Grabinsky et al. 2022). An attempt was made to characterise the strength of cold joints in paste fill from the Lucky Friday Mine with inconclusive results (Johnson et al. 2015). Synthetic discontinuities have previously been generated in the laboratory associated with cemented paste backfill by Nasir and Fall (2008) and Koupouli et al. (2017). These studies considered the strength of the CPB – rock interface and not any internal discontinuities. This project will consider the strength of the internal discontinuities.

References:

Johnson JC, Seymour JB, Martin LA, et al (2015) Strength and elastic properties of paste backfill at the Lucky Friday Mine, Mullan, Idaho. 49th US Rock Mech / Geomech Symp 2015 3:2321–2332

Key words: Cold joint, Tension strength, Shear strength, Cemented paste backfill and Mining

Principal Supervisor:	Prof Bre-Anne Sainsbury
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Impact Theme	Enabling a sustainable world
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
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More information	Contact sebe-hdr-admissions@deakin.edu.au

Biochar composite technologies for carbon storage and regenerating water and soil landscapes

Abstract: You will research biochar composite technologies such as wood/crop wastes blended with beneficial trace elements and nutrients. The biochar composites can be optimized and scaled at industry pyrolysis sites, designed for applications in carbon storage and regenerating water and soil landscapes. There are many benefits of biochar composite technologies for agriculture, horticulture, mine site regeneration and a growing market for carbon sequestration. Biochar is a nature-based solution for the environment at both small site scale and large industrial plant scale, with research opportunities to enhance co-benefits for water and nutrient availability within a stable carbon structure (e.g. natural fertilizers).

References:

Adhikari, S, P Mahmud, M D Nguyen, Timms, W. 2023. Evaluating fundamental biochar properties in relation to water holding capacity. Chemosphere journal. 328:138620. Link

Adhikari et al. 2022, Optimising water holding capacity and hydrophobicity of biochar for soil amendment–A review. Science of The Total Environment, 158043. Link

Adhikari S, E Moon, W Timms. Boosting confidence in biochar product value for carbon removal and multiple co-benefits – an Australian perspective. Global ESG Forum, Singapore, June 2023.

Timms W, S Adhikari, Z Zhou, S Joseph. Biochar to store carbon and water – engineering biochar designed for climate resilience in agriculture and mine site regeneration. Engineers Australia, Climate Resilience Conference, Melbourne, Nov 2023.

Key words: Carbon storage, Biochar, Pyrolysis, soil and Water

Principal Supervisor:	Prof Wendy Timms
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Impact Theme	Creating smarter technologies
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Additive manufacturing of NiTi shape memory alloys by laser powder bed fusion

Abstract: Laser powder-bed fusion (LPBF) is a mainstream additive manufacturing (AM) process that creates a 3D object using a high-power laser to fuse fine metallic particles. Over the past decade, LPBF has received significant attention due to its capability in producing dense parts with superior mechanical properties. As a premier shape memory alloy, the nickel-titanium (NiTi) shape memory alloy (SMA) is attractive for actuation and biomedical applications due to its shape memory characteristic, superelasticity, corrosion resistance and biocompatibility. This project aims to additively manufacture Ni50.2Ti49.8 SMA using LPBF followed by critical evaluation on its achievable microstructures and mechanical/functional properties. Depending on the thermal history experienced during LPBF, the constituent phases present in the as-built state of Ni50.2Ti49.8 possibly vary from austenite (B2) to a mixture of B2 and other phases such as martensite (B19) or R-phase, or to R-phase as the dominant phase. Consequently, the resultant mechanical and functional properties tend to vary, accordingly. The objectives of this project include: 1) Define the appropriate LPBF process window for the manufacture of Ni50.2Ti49.8 with minimal porosity; 2) Identify the constituent phases present in LPBF Ni50.2Ti49.8 and heat-treated counterparts; 3) Evaluate mechanical/functional properties of LPBF Ni50.2Ti49.8 and heat-treated counterparts.

References:

L. Xue, K.C. Atli, C. Zhang, N. Hite, A. Srivastava, A.C. Leff, A .A . Wilson, D.J. Sharar, A. Elwany, R. Arroyave, I. Karama. Laser Powder Bed Fusion of Defect-Free NiTi Shape Memory Alloy Parts with Superior Tensile Superelasticity. Acta Materialia vol. 229, 2022, 117781.

Key words: Additive manufacturing, NiTi shape memory alloy, Superelasticity, Mechanical properties and Microstructural control

Principal Supervisor:	A/Prof Wei Xu
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Alloy development and additive manufacturing of novel titanium aluminide for high-temperature applications

Abstract: Titanium Aluminides (TiAl) can be used at application temperatures of up to 750 – 850 °C due to their high specific strength and stiffness, oxidation resistance, and good creep properties. They are light compared to existing high temperature materials. These are candidate materials for high temperature applications including Aircraft Pylon Heat Shield, Aero-Engines, future Supersonic & Hypersonic Air Vehicles. However, they are brittle in nature. A new Titanium Aluminide combined with new processing techniques like Additive Manufacturing is anticipated to enable improved performance and open up applications especially in Aerospace. The main aims of this project include: i) development of a new high temperature alloy – Titanium Aluminide with higher temperature capability, lower brittleness etc. ii) additive manufacturing to make aerospace components from this new alloy using two mainstream AM techniques: wire-arc AM, and friction stir AM (MELD). iii) advanced material characterization.

References:

Ozge Genc, Rahmi Unal. Development of gamma titanium aluminide (γ-TiAl) alloys: A review. Journal of Alloys and Compounds, vol. 929, 2022, 167262.

Key words: Additive manufacturing, titanium aluminide, microstructural control, mechanical properties, high-temperature mechanical performance

Principal Supervisor:	A/Prof Wei Xu
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Impact Theme	Creating smarter technologies
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Microstructural control in laser powder-bed fusion additively manufactured Ti-6Al-4V

Abstract: Laser powder-bed fusion (L-PBF) additive manufacturing (AM) is an advanced manufacturing process where a three-dimensional (3D) metal part is built layer-by-layer by selectively fusing powder particles with a high-energy laser beam. To continually forge ahead into manufacturing sectors where fracture-critical components are broadly used, it is imperative to unlock the potential of metal AM in making quality parts with consistent and reliable mechanical performance. This is still in its infancy of development and remains beyond the reach of the current L-PBF practice. As such, it continues to be a core challenge confronting the AM community, particularly when producing Ti-6Al-4V, a high utility titanium alloy in aerospace and biomedicine due to its superior mechanical and corrosion properties. In particular, the nature of rapid cyclic heating and cooling in metal AM poses a great challenge in the control of microstructure. This project aims to achieve real-time control of the microstructure spatially and temporally while a Ti-6Al-4V part is being built using L-PBF, by means of process optimization for localized thermal control.

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Key words: Additive manufacturing, Ti-6Al-4V, microstructural control, mechanical properties, laser powder-bed fusion

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Modelling and Control of Solar PV Integrated EV Charging System with Grid Support Capability

Abstract: The large-scale integration of electric vehicle (EV) into the distribution grid can introduce technical challenges disrupt power grid codes and standards [1],[2]. The EV charging systems interact with power grid through inverter-based resources (IBR) which affect grid operation and increase complexity of the power grid. The EV charging systems may cause an unpredicted peak and overloading distribution network which can cause power loss and impacts on stability, voltage and frequency regulation and dispatch of energy sources [3],[4]. However, the coordinated control of EV charging system in vehicle to grid (V2G) and grid to vehicle modes (G2V) can enhance grid stability, power quality, efficiency and reliability by providing ancillary services utilising EV battery storage [5]. The aims and objectives of this project include:

• Impact assessment of EV integration on power grid in terms of voltage/frequency stability, power quality and harmonics

• Development of a model for EV charging infrastructure integrated with the distribution network and solar PV.

• Development of algorithm for coordinated and resilient data-driven control for solar PV integrated EV charging system in grid forming modes for optimised charging and ancillary grid services

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Key words: Electric vehicle, Solar PV, Control, Grid forming inverter and Ancillary services

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Deep Learning for Renewable Energy Management Systems

Abstract: Optimising the renewable energy management system (REMS) in smart grids (SG) is highly important to increase operational efficiency, lower energy costs, and guarantee grid stability. Renewable energy sources (RES) exhibit high variability and uncertainty. As a result, it has become extremely challenging to efficiently manage such systems with the rapid expansion of RES in power system networks. Conventional analytical techniques require a lot of computations and time to process the massive amount of data from smart grids enabled by RES and advanced metering infrastructure. Different deep-learning (DL) algorithm, such as reinforcement learning (RL) methods enabled by appropriate optimization techniques can be used to predict different aspects of REMS as well as analyse the enormous amount of smart grid data with a greatly decreased computational complexity. In this project, deep leaning algorithms such as recurrent and convolutional neural networks will be developed with the reinforcement mechanism to capture complex relationships between renewable energy generation, demand, and external factors dynamically. The deep learning models with be integrated with different optimization algorithms, which will utilize the predictions from the deep learning models to make real-time decisions on energy dispatch, storage, and demand response.

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Devinder Kaur, Shama Naz Islam, Md Apel Mahmud, Md Enamul Haque, Adnan Anwar (2023), A VAE-Bayesian deep learning scheme for solar power generation forecasting based on dimensionality reduction, Energy and AI, 100279

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Key words: Deep learning, Energy management systems, Optimisation and Data analytics

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Cyber Resilient Coordinated Control and Smart Energy Management for Renewable Rich Microgrid

Abstract: The rapid increase in the integration of intermittent renewable-based microgrids into the distribution network impacts grid stability, security, and resiliency [1], [2]. The use of communication technologies and the Internet of things (IOT) with the renewable-based microgrid system enable the distribution system network operators (DNSPs) to control and manage the to provide ancillary grid services such as voltage/frequency stability and load management [3]-[5]. The successful implementation of these smart controllers requires communication technologies and IOT infrastructure that brings increased observability, automation, and control capabilities. However, this increased dependency on the cyberinfrastructure makes the power grid vulnerable to cyber-attacks. To ensure better utilization of microgrid facilities and infrastructure, a smart control and energy management algorithm is necessary considering system stability, security, and resiliency. This project, therefore, is proposing a smart cyber resilient coordinated control and energy management approach for a renewable rich microgrid integrated with a distribution network. The aims and objectives of this project include: • Cyber security risk assessment of renewable-rich microgrid with smart inverter • Cyber-physical modeling of Microgrid system with associated smart converter and controllers • Development of cyber resilient coordinated control and data-driven smart energy management algorithm for renewable rich microgrid The proposed research will enable the DNSPs to mitigate challenges for large-scale integration of renewable-based microgrids and find remedial measures. The research outcome will enable the distribution grid to make a contribution to enhance system stability, cost reduction, and security.

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Key words: Microrgid, Cyber-resilient control, Smart enegry management and Risk assessment

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A Grid Interactive Solar PV–Fuel Cell–Electrolyzer Microrgid System with Grid support capability

Abstract: The power flow from a grid-connected Solar Photovoltaic (PV) or wind energy system is highly variable and creates complexities in the power scheduling for the utility. A sudden and large variation in power from the intermittent renewable energy sources (RES) can affect the power quality or even stability of the grid. Alternate energy source like fuel cells (FC) improve the performance of the hybrid system in a microgrid. The power output from these energy sources is controllable. When used along with an RES, the output power of the combined system will have lesser variations. FC have a lot of prospects to be used along with RES-based hybrid systems. FC can combine with renewable energy resources to improve the reliability and performance of the power system. Moreover, in the coming future of the transportation sector, FC electric vehicles (FCEV) will have a major role to generate electricity and provide ancillary services to the grid. The main aims and objectives of this project include: • Design and modeling of solar PV-Fuel cell-Eletrolyser based microgrid with associated power electronic converters. • Develop Control and energy management algorithms for the hybrid system • Develop advanced control techniques to provide ancillary services to distribution grid utilizing Fuel cell system The proposed research will enable the power grid operator to mitigate challenges for large-scale integration of renewable-based microgrids and find remedial measures. The research outcome will enable the distribution grid to contribute to enhancing system stability, reliability, and energy efficiency.

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Key words: Solar PV, Fuel cell, Electrolyser and Ancillary services

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Techno-economic Analysis of Optimum Peer-to-Peer Energy Trading Strategies

Abstract: The energy demand across the world has been increasing exponentially over the past decade. There has been a widespread growth of small-scale distributed energy generation, which utilises the energy derived from renewable resources to support low-carbon electricity production techniques and schemes initiated by governments. This encompasses rooftop solar systems, behind-the-meter generation, residential energy storage systems and electric vehicle applications. To promote such local energy generation projects, many countries are offering incentives for microgrids, a miniature version of the utility grid with local generation and demand. This has instigated next generation techniques, called peer-to-peer (P2P) energy trading, where the prosumers/consumers can buy or sell energy locally, which reduces their dependence on the utility grid. It is important to investigate different market models and pricing strategies for enabling an in-depth techno-economic analysis of effective P2P energy trading mechanisms. In addition, there should be appropriate consideration of user preferences and behavioural patterns, without which the cost-effectiveness of such mechanisms cannot be achieved. In this PhD project, optimum P2P energy trading strategies considering different market models as well as pricing structures will be developed with an aim to achieve a trade-off between the profit and social utility objectives.

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Key words: Peer to peer energy trading, Double auction, Pricing, Renewable energy and Microgrid

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Enabling the transitioning of passive DER to active DER for better and effective use of energy from DERs

Abstract: The distributed energy resources (DER) integration into the grid is continuously increasing and at present the most prominent form of DER is solar PV which has the largest penetration in the low voltage (LV) distribution network. This PV DER acts as a passive generator that injects power when there is solar irradiation. Moreover, the distribution of the rooftop-type PV DER is not homogeneous across the network. The larger integration of PV DERs can change the network profile, can introduce a duck curve and the distribution network can face significant challenges to manage the network power quality. With the goal to reduce grid risk and to best use of DER-generated power, Battery as energy storage is integrating along with PV at the distribution network. Moreover, with rising global demand electric vehicles (EV) will be an additional common form of DER at the consumer premises. Therefore, at the user level, multiple DERs will make the distribution part of the network more complex and vulnerable to maintaining power quality. This project aims to transform passive DERs into active and provide automated, real-time control strategies for DER coordination that enable network operators to orchestrate for active management of the network.

References:

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Tavakoli, A., S. Saha, M. T. Arif, M. E. Haque, N. Mendis and A. M. T. Oo (2020) "Impacts of grid integration of solar PV and electric vehicle on grid stability, power quality and energy economics: a review." IET Energy Systems Integration 2, 243-260.

Key words: Distributed energy resources (DER), Power Quality, Control and Energy management

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Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship

Control and management of PV, Battery, and Hydrogen Fuel Cell (H2FC) based isolated microgrid

Abstract: Access to reliable and sustainable energy is still a challenge for remote off-grid communities. Diesel generator is used in most cases to meet the necessary energy demand which is costly as well as contributing to emissions. Although solar PV is offsetting the use of diesel generators partly, but due to high fluctuations of solar irradiation it is unable to provide the power supply reliably. There are different other distributed energy resources (DER) available, but it is difficult to find a sustainable solution to provide quality power to users. Hydrogen (H2) as an energy carrier and energy storage is highly promising for power system applications with the use of Fuel Cell (FC). This project aims to integrate H2 as storage along with battery and solar PV to form a hybrid microgrid and offset the use of diesel generators. This will ensure secure and reliable energy from renewable energy-based hybrid microgrid. The key objective is to develop an appropriate control strategy to operate this hybrid system as well as to ensure optimum energy management for reliable, cost-effective and sustainable microgrid operation.

References:

Altaf, M. W., M. T. Arif, S. N. Islam and M. E. Haque (2022). "Microgrid Protection Challenges and Mitigation Approaches–A Comprehensive Review." IEEE Access 10: 38895-38922. Link

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Key words: Microgrid, Solar PV, Battery, Hydrogen Fuel Cell and Control

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Modelling, control and implementation of grid forming inverter for sustainable renewable energy applications

Abstract: Global energy consumption is expanding due to improved economic conditions and rising demand for heating and cooling applications. Moreover, global transport applications are also transforming towards electric mode to reduce emissions. To reduce emissions from the energy sector various renewable energy (RE) sources are supporting loads and integrating into the distribution grid. Therefore, power systems are increasingly augmented with inverter-based energy resources (IBER) such as solar PV, wind turbines, battery storage, electric vehicles, hydrogen Fuel Cells etc. The inverters in their current form are following the grid for their applications and integration of RE sources to the grid. However, RE sources or IBERs are experiencing growing demand for mimicking the behaviour of synchronous generators which is not feasible with the conventional grid following inverters. This project aims to develop and implement grid grid-forming inverter for the seamless transitioning of microgrids from grid-connected mode to islanded mode and vice versa. This will enable microgrid to maintain the regulatory framework (voltage, frequency, stability etc.) and enhance RE applications.

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Rathnayake, D. B., M. Akrami, C. Phurailatpam, S. P. Me, S. Hadavi, G. Jayasinghe, S. Zabihi and B. Bahrani (2021). "Grid Forming Inverter Modeling, Control, and Applications." IEEE Access 9: 114781-114807. Link

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Altaf, M. W., M. T. Arif, S. N. Islam and M. E. Haque (2022). "Microgrid Protection Challenges and Mitigation Approaches–A Comprehensive Review." IEEE Access 10: 38895-38922. Link

Fazal, S., M. Enamul Haque, M. Taufiqul Arif, A. Gargoom and A. M. T. Oo (2023). "Grid integration impacts and control strategies for renewable based microgrid." Sustainable Energy Technologies and Assessments 56: 103069. Link

Altaf, M. W., M. T. Arif, S. N. Islam and M. E. Haque (2022). "Microgrid Protection Challenges and Mitigation Approaches–A Comprehensive Review." IEEE Access 10: 38895-38922. Link

Key words: Renewable energy, Grid forming inverter, Microgrid and Control

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Durability assessment of natural fibre reinforced geopolymer concrete

Abstract: Sustainable construction materials are in needs to reduce CO2 emissions in the environment. Geopolymer being an emergent sustainable construction material had been extensively studied. However, its brittleness is still the main issue to be overcome. Hence, in this research, natural fibres as environmental-friendly low-cost material will be introduced to enhance the overall quality of the geopolymer. The study will introduce a potential sustainable construction material like Natural Fibre Reinforced Geopolymer Concrete (NFRGC) which will be studied via experimental tests. The effects of different lengths and different volume fractions of a few natural fibres on the engineering properties of the fibre composite geopolymer concrete will be measured. The compressive strength, splitting tensile strength and flexural strength of the fibre composite geopolymer concrete will be measured. Furthermore, the durability aspects will also be measured from the experimental tests which can provide a significant information on increasing the longevity of the geopolymer concrete structure.

References:

Abbas, A. G. N., Aziz, F. N. A. A., Abdan, K., Nasir, N. A. M., & Huseien, G. F. (2023). Experimental evaluation and statistical modelling of kenaf fibre-reinforced geopolymer concrete. Construction and Building Materials, 367, 130228. Aswani, E., & Karthi, L. (2017). A literature review on fibre reinforced geopolymer concrete. Int. J. Sci. Eng. Res, 8(2), 408.

Key words: Natural Fibre Reinforced Geopolymer Concrete (NFRGC), Stainable and Construction materials

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Phosphorus Removal in Bioretention Basins

Abstract: Bioretention basins are a class of green infrastructure engineered for the management of stormwater. Contaminants contained in stormwater are biofiltered in bioretention systems via physical, chemical and biochemical pathways. This project will study phosphorus removal in bioretention basins. The project involves experimental work in the laboratory and numerical modelling, and possibly field work. The student is expected to have knowledge of adsorption kinetics/chemistry, basic laboratory analysis skills. Some knowledge of numerical modelling, preferably conversant in MATLAB is desired, but not essential, so long as the student is keen to develop this skill. The student will continue from previous student's modelling work and will have to adapt an existing model for treatment of phosphorus.

References:

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Wang, Jia; Chua, Lloyd HC; Shanahan, Peter. Modelling and designing for nitrogen removal in bioretention basins. Environmental Modelling & Software. 146, 105212, 2021.

Key words: Bioretention, Phosphorus, Adsorption, Modelling and Numerical

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Hydrodynamic and ecological modelling of floating PV systems

Abstract: Floating photovoltaic panels have gained popularity recently. While the energy generation aspects are extensively studied, its impact on hydrodynamics and water quality is not known. This project looks at the potential impacts placing floating PV panels placed on the surface of a waterbody can have on hydrodynamics and ecological behaviour. The student involves mainly data analysis and numerical modelling. Some fieldwork may be required. The student is expected to have skills in data assimilation, and data analysis, mostly dealing with time series data. Some experience with numerical modelling is essential, or the student is at least expected to have an appreciation of numerical modelling. Coding experience is desired; although the source code for the model exists, the student is expected to make modifications to an existing model.

References:

Yang, Peipei; Chua, Lloyd HC; Irvine, KN; Imberger, Jorg. Radiation and energy budget dynamics associated with a floating photovoltaic system. Water Research, 206, 117745, 2021.

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Key words: Floating PV, Modelling, Lake, Numerical and Hydrodynamics

Principal Supervisor:	A/Prof Lloyd Chua
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Complex fatigue of metal repaired parts using 3D printing

Abstract: Engineering structures subjected to cyclic loading in service eventually suffer fatigue damage. Typical examples include wear and rolling contact fatigue in railway rails, wear of metal forming tools and fatigue cracks in primary aircraft structures. Repair or rebuilding of worn and damaged structures is one of the effective maintenance approaches to extend component lives. Metal Directed Energy Deposition (DED) or more specifically - Direct Laser Metal Deposition (DLMD), is a promising 3D printing technique for repair applications because it produces a strong metallurgical bond onto the substrate and can use a wide range of deposition materials. The advantages of DLMD for repair also include lower heat input, superior process control, and a narrow heat-affected zone. To-be-remanufactured components normally have damage on the surface due to wear or fatigue under cyclic loading conditions. The remanufactured components in service will be subjected to the same loading condition as the original component. To confidently apply DLMD for remanufacturing, especially for large metallic components, it is vital to know the remaining service life of a remanufactured component. Currently, studies are lacking on predicting the remaining service life of a remanufactured component and on how residual stress affects the remaining life.

References:

M Liu, LNS Chiu, C Vundru, Y Liu, A Huang, C Davies, X Wu, W Yan (2021). Addit Manuf 44, 102026.

Key words: Repair, fatigue, 3D printing, Additive Manufacturing

Principal Supervisor:	Prof Bernard Rolfe
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Impact Theme	Smart technologies and advanced manufacturing
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship
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Bridging time and length scales when modelling metal microstructure evolution

Abstract: To study the effect of process parameters on the microstructure, traditional experiments can be conducted by trial-and-error methods using combinations of processing conditions. But this requires many resources and is an unreasonably large time-consuming task. Therefore, the process designers rely on computational modelling techniques to overcome the challenges associated with experiments. However, given that the microstructural evolution at the intra-grain and inter-grain scale are taking place at different length and time scale, it is difficult to solve them simultaneously in a single physics-based model. Therefore, they are mostly modelled separately at the relevant length and temporal scales. After the models are complete and run can the information between the two scales (inter-grain and intra-grain) then be exchanged at the interface, that is, a resolved scale based multiscale method. However, physics-based models have high computational costs. This project will investigate developing alternative meta models for bridging these scales.

References:

V. Vaithyanathan, C. Wolverton and L. Chen, 'Multiscale modeling of θ precipitation in al–cu binary alloys', Acta Materialia, vol. 52, no. 10, pp. 2973– 2987, 2004.

Key words: Modelling, Microstructure Evolution, Artificial Intelligence and Multi-scale

Principal Supervisor:	Prof Bernard Rolfe
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Impact Theme	Creating smarter technologies
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Dewatering of ultra-fine tailings: Towards dry tailings storage

Abstract: The mining industry is one of the largest producers of solid waste in the world. Roughly one third of the waste produced is in the form of tailings, a slurry of fine particles with high water content. Slow to sediment, tailings are geotechnically unstable. Tailings are typically stored in enormous dams, contained by embankment dams that can be tens of metres high. Tailings dam failures can be catastrophic, releasing millions of cubic metres of toxic mud onto anything downstream - which can often include communities, farmland and sensitive ecosystems. To avoid these issues, dry stacking of tailings is increasingly preferred, but requires dewatering of tailings to very low moisture contents. This is made more challenging by the increasingly finer grinding of ore material, which is needed as ore grades decrease. This project seeks to improve the solid-liquid separation in tailings, and to ultimately find new ways to dewater tailings contain ultra-fine materials.

References:

Fawell, P. (2017). Solid-liquid separation of clay tailings, Cambridge University Press: Cambridge: 327-380

Usher, S. P., R. G. De Kretser and P. J. Scales (2001). "Validation of a new filtration technique for dewaterability characterization." AIChE Journal 47(7): 1561-1570.

Key words: Mineral processing, Chemical engineering and Dewatering

Principal Supervisor:	Dr Ellen Moon
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Impact Theme	Enabling a sustainable world
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Hydrogen fuel cell in vehicles: Australian context

Abstract: This project investigates the utilisation of hydrogen fuel cells in vehicles on-road in Australia to decarbonise and reduce the amount of using fossil fuels in the transportation sector.

The specific objectives of this project are:

• Performance characteristics of hydrogen fuel cell powered vehicles as compared to battery electric, hybrid hydrogen fuel cell, and internal combustion engine vehicles. The modelling study will be done in AVL software.

• Impact of Australian road and weather conditions on hydrogen fuel cell performance.

• Life-cycle analysis and economic feasibility of hydrogen fuel cells in Australian vehicle fleet.

• Feasibility of using hydrogen fuel cells in Australian vehicle fleet: Hydrogen fuel cell and Hybrid hydrogen fuel cell.

References:

Salek, F., Abouelkhair, E., Babaie, M., Cunliffe, F., & Nock, W. (2023). Multi-Objective Optimization of the Fuel Cell Hybrid Electric Powertrain for a Class 8 Heavy-Duty Truck (No. 2023-01-0473). SAE Technical Paper.

Aminudin, M. A., Kamarudin, S. K., Lim, B. H., Majilan, E. H., Masdar, M. S., & Shaari, N. (2023). An overview: Current progress on hydrogen fuel cell vehicles. International Journal of Hydrogen Energy, 48(11), 4371-4388.

Key words: Hydrogen fuel cell, Alternative fuel and Vehicle

Principal Supervisor:	Dr Ali Zare
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Advancing IoHT-Driven Multimodal Neurocognitive Assessment Techniques

Abstract: Advancing IoHT-Driven Multimodal Neurocognitive Assessment Techniques: In the rapidly evolving domain of neurocognitive research, drawing definitive relationships between brain dynamics and behavior necessitates sophisticated analytical methodologies. "Advancing IoHT-Driven Multimodal Neurocognitive Assessment Techniques" delves into this challenge, employing cutting-edge signal processing and advanced machine learning algorithms to decode the multifaceted data generated through diverse assessment modalities. Harnessing the power of the Internet of Health Things (IoHT) and aligning with the tenets of Health 5.0, our methodology ensures seamless data acquisition, real-time processing, and cloud-based integrative analyses. This robust approach enables the extraction of intricate patterns and relationships, previously obscured in traditional unimodal analyses. Literature findings illustrate the efficacy of feature engineering and deep learning architectures in enhancing the resolution and interpretability of cognitive evaluations. This research, anchored at the confluence of engineering, data science, and cognitive neuroscience, signals a transformative direction for neurocognitive assessments, bearing immense potential for precision diagnostics and personalized interventions in a Health 5.0 paradigm.

References:

Storrs, K. R., & Kriegeskorte, N. (2019). Deep learning for cognitive neuroscience. arXiv preprint arXiv:1903.01458.

O'reilly, R. C., & Munakata, Y. (2000). Computational explorations in cognitive neuroscience: Understanding the mind by simulating the brain. MIT press.

Key words: IoHT, Computational cognitive neuroscience, Applied AI and Advanced signal processing

Principal Supervisor:	Dr Bipasha Kashyap
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Campus	Geelong Waurn Ponds
Impact Theme	Creating smarter technology
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship
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Biomedical Device design for the assessment of Neurological Disorders

Abstract: Our team has successfully used IoT based Wearable and non-wearable sensors for the quantitative assessment of Neurological disorders. This project is looking at the data analytics and machine learning implementations as well as the improved security and privacy of data in a cloud and edge computing-based settings.

References:

Ngo, T., Pathirana, P.N., Horne, M., Power, L., Szmulewicz, D. J., Milne, S., Corben, L., Roberts, M., Delatycki, M., "Balance Deficits due to Cerebellar Ataxia: A Machine Learning and Cloud-Based Approach," in IEEE Transactions on Biomedical Engineering, vol. 68, no. 5, pp. 1507-1517, May 2021, Link.

T. Ngo, D.C. Nguyen, P.N. Pathirana, L.A. Corben, M.B. Delatycki, M. Horne, D.J. Szmulewicz, "Federated Deep Learning for the Diagnosis of Cerebellar Ataxia: Privacy Preservation and Auto-Crafted Feature Extractor," in IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 30, pp. 803-811, 2022, Link.

D. C. Nguyen, S Hosseinalipour, D. Love, P.N. Pathirana and C.Brinton, "Latency Optimization for Blockchain-Empowered Federated Learning in Multi-Server Edge Computing", IEEE Journal on Selected Areas in Communications, 40:3373-3390, 2022 4)8

D. Nguyen, M. Ding, P. Pathirana, A. Seneviratne, J. Li and V. Poor, "Cooperative Task Offloading and Block Mining in Blockchain-based Edge Computing with Multi-agent Deep Reinforcement Learning", IEEE Transactions on Mobile Computing, Link.

R. Krishna, P. N. Pathirana, M. K. Horne, D. J. Szmulewicz and L. A. Corben, "Objective Assessment of Progression and Disease Characterization of Friedreich Ataxia via an Instrumented Drinking Cup: Preliminary Results", in IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 29, pp. 2365-2377, 2021, Link.

Key words: Motion capture, Biomedical Engineering, Computer networks, Security and Privacy, Machine and Deep learning

Principal Supervisor:	Prof Pubudu Pathirana
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Impact Theme	Improving health and wellbeing
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship
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An AI-enabled IoT platform to improve indoor plant growth.

Abstract: This project is focussed on the further development of an existing AI-IoT platform designed to optimise plant yields. By integrating a number of advanced technologies, the platform enables real-time monitoring and control of environmental factors crucial for plant growth. This platform allows us to address traditional challenges in maintaining optimal conditions through data-driven insights. Theoretical Background: The development of new crop varieties demands precise management of variables like light, humidity, and nutrients. Our generation 1 technology enables this experimentation to be completed in a efficient and cost-effective way. This project aims to enhance our existing platform by integrating AI-driven analysis of sensor data in order to investigate predictive analytics, dynamic plant responses to time-sensitive treatments as well as to assist in advanced plant breeding techniques. Expected Impact: The AI-IoT platform is poised to revolutionize plant experimentation. Enhanced yields are anticipated due to fine-tuned conditions. Efficient resource usage, remote management capabilities, and data-derived insights contribute to sustainability and informed decision-making. The project holds potential for extremely broad applications, from urban farming to large-scale agriculture. In conclusion, we are looking for a student interested in working on a novel and new technology assisting in the development of precision agriculture. Through real-time analysis and control, it offers a scalable solution for optimising plant yields, assisting in scientific investigations, fostering sustainable practices and improving resource efficiency.

References:

Ghosh, S., Watson, A., Gonzalez-Navarro, O.E., Ramirez-Gonzalez, R.H., Yanes, L., Mendoza-Suárez, M., Simmonds, J., Wells, R., Rayner, T., Green, P., Hafeez, A., Hayta, S., Melton, R.E., Steed, A., Sarkar, A., Carter, J., Perkins, L., Lord, J., Tester, M. and Osbourn, A. (2018). Speed breeding in growth chambers and glasshouses for crop breeding and model plant research. Nature Protocols, [online] 13(12), pp.2944–2963.

Vernon, M., Kouzani, A.Z., Webb, L.D. and Adams, S. (2023). A Survey of Modern Greenhouse Technologies and Practices for Commercial Cannabis Cultivation. IEEE Access, 11, pp.62077–62090.

Key words: IoT, AI, Plants, Sustainability and Control Engineering

Principal Supervisor:	Dr Scott Adams
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Impact Theme	Creating smarter technology
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Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship
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Integrated AI algorithm and Neuromorphic Hardware for Healthcare Applications

Abstract: The integration of sensors, data collection and preprocessing methods, AI algorithms, neuromorphic hardware, and communications and IoT devices has the potential to revolutionise the way we diagnose, treat, and prevent health disorders. It could be used to improve the accuracy, speed, and efficiency of early disease detection, personalised medicine, disease therapy, among others. Depending on the applicant's interest a PhD project is tailored in this space. As an example, sensors, AI algorithms, and neuromprophic hardware can be used to detect and or predict mental illnesses. Prof Kouzani is the Director of Smart Technologies Research Theme within the School of Engineering. He has been involved in over $20 million research grants, published over 500 papers, and holds several patents. He has supervised over 35 PhD candidates to completion. He has carried out research for over 40 companies. A successful scholarship recipient would be considered for additional support.

References:

Zhang, Z. and Kouzani, A.Z., 2021. Resource-constrained FPGA/DNN co-design. Neural Computing and Applications, 33(21), pp.14741-14751

Nouman, M., Khoo, S.Y., Mahmud, M.P. and Kouzani, A.Z., 2021. Recent advances in contactless sensing technologies for mental health monitoring. IEEE Internet of Things Journal, 9(1), pp.274-297.

Key words: Artificial Intelligence, Data Analysis, Healthcare, Image/Signal/Video and Neuromorphic Hardware

Principal Supervisor:	Prof Abbas Kouzani
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Impact Theme	Creating smarter technology
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Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship
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Conversational AI for Tackling Domestic Violence

Abstract: Domestic violence is an issue of great importance that leads to physical injuries, psychological trauma, and even death. This research project aims to design and implement a conversational artificial intelligence (AI) system that collect data from ambient sensors and engages in human-like conversations with individuals to automatically detect an individual experiencing domestic violence or being at risk of experiencing domestic violence. Prof Abbas Kouzani is the Director of Smart Technologies Research Theme within the School of Engineering. He has been involved in over $20 million research grants, published over 500 papers, and holds several patents. He has supervised over 35 PhD candidates to completion. He has carried out research for over 40 companies. A successful scholarship recipient would be considered for additional support.

References:

Kouzani, A.Z., 2023, Technological Innovations for Tackling Domestic Violence, IEEE Access, Link

Key words: Artificial Intelligence, Ambient Sensors, Chat, Detection and Prediction and Domestic Violence

Principal Supervisor:	Prof Abbas Kouzani
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Impact Theme	Creating smarter technology
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship
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Hybrid Energy System for Drones

Abstract: Drones are rapidly growing as powerful tools for rapid inspection and delivery applications in military, law-enforcement, energy, construction, agriculture, infrastructure, entertainment, and healthcare sectors. Their global commercial market is estimated to be over $5 billion per annum and growing. However, currently they can only perform short flights, and transport light payloads. These debilitating shortcomings are due to the following technological bottleneck: low capacity and large weight of their energy storage systems. This project aims to design, implement, and validate a dedicated hybrid energy storage system for drones to tackle the listed shortcoming of their current energy storage systems. A dedicated hybrid energy storage system will be designed, implemented, and validated. The state-of-the-art new battery, supercapacitor, fuel cell, and renewable technologies will be explored, together with electronic circuitry, and artificial intelligence algorithms to develop the proposed dedicated hybrid energy storage system. Prof Abbas Kouzani is the Director of Smart Technologies Research Theme within the School of Engineering. He has been involved in over $20 million research grants, published over 500 papers, and holds several patents. He has supervised over 35 PhD candidates to completion. He has carried out research for over 40 companies. A successful scholarship recipient would be considered for additional support.

References:

Corva, D.M., Adams, S.D. and Kouzani, A.Z., 2021. Variable-geometry exit nozzle for improving static thrust of drones ducted fans. Journal of Field Robotics, 38(8), pp.1092-1103.

Key words: Artificial Intelligence, Battery, Drone, Fuel Cell and Hybrid Energy System

Principal Supervisor:	Prof Abbas Kouzani
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Impact Theme	Creating smarter technology
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship
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Road safety perception of cyclists in current and future traffic environments using Virtual Reality (VR)

Abstract: Innovations in cycling infrastructure design and planning are being made across the world, including adoption of the innovative designs for encouraging greater cycling participation and improving the safety of cyclists. Previous research indicated that cyclists' perception of safety at different types of infrastructure and their innovative designs influence cycling behaviour and how these infrastructures are utilised. Understanding safety perception of cyclists will provide the valuable information for improving the utilisation rates of these infrastructures as well as to better inform the planning of such infrastructure in the future, with the integration of Connected and Automated Vehicles (CAVs) and micro-mobility users to existing motorised traffic scenarios. This project aims to examine cyclists' safety perception of various infrastructure types in interactions with motorised traffic, including connected and automated vehicles (CAVs), using Virtual Reality (VR) experimental studies and advanced data analytics. Findings obtained from this project will provide useful insights in proactive design and planning of cycling infrastructure.

References:

Ng, A., Debnath, A.K., and Heesch, K. (2017) Cyclist' Safety Perceptions of Cycling Infrastructure at Un-signalised Intersections – Cross-sectional Survey Study of Queensland Cyclists. Journal of Transport and Health, 6, 13-22.

Debnath, A.K., Haworth, N., Heesch, K.C. (2021) Women cycling in Queensland: Results from an observational study. Accident Analysis and Prevention, 151, pp. 137-142.

Debnath, A.K., Haworth, N., Schramm, A., Heesch, K.C., Somoray, K. (2018) Factors influencing noncompliance with bicycle passing distance laws. Accident Analysis and Prevention, 115, pp. 137-142.

Haworth, N., Heesch, K., Schramm, A.., Debnath, A.K. (2018) Do Australian drivers give female cyclists more room when passing? Journal of Transport and Health, 9, 203-211.

Wahi, R.R., Haworth, N., Debnath, A.K., and King, M. (2018) Influence of type of traffic control on injury severity in bicycle-motor vehicle crashes at intersections. Transportation Research Record 2672 (38), 199-209.

Key words: Transportation Engineering, Road Safety, Cycling, Road design and Behavioural analysis

Principal Supervisor:	A/Prof. Ashim Debnath
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Impact Theme	Building safe and secure communities
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
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Proactive roadwork design, traffic management and safety modelling

Abstract: Roadworks is a common activity in Australian roads. Recent infrastructure development commitments from the Australian Government indicate that many Australian drivers will experience considerable amount of travel through roadworks in the coming years. While increase in roadworks imply improvement in overall road infrastructure for Australia, roadworks itself attract some undesirable impacts to road users, such as delays, frustration, and safety critical incidents. To reduce such impacts, this research will develop new fundamental models of traffic safety at roadworks so that the contexts and factors of safety events at roadworks are better understood and comprehensively addressed. This research will generate significant knowledge in managing traffic at roadworks through development of various models of traffic safety. Utilising a range of traffic flow models, traffic simulation, video analytics, and statistical methods, this research will develop efficient and safer ways of managing traffic at roadworks.

References:

Debnath, A.K., Blackman, R., and Haworth, N. (2014) A Tobit model for analyzing speed limit compliance in work zones. Safety Science, 70, 367-377.

McClure, D., Siriwardene, S., Truong, L., Debnath, A.K. (2023) Examination of Crash Rates and Injury Severity Before, During, and After Roadworks at High-speed Regional Roads. Transportation Research Record, in press.

Debnath, A.K., Haworth, N., Blackman, R. (2021) Risk to Workers or Vehicle Damage: What makes drivers slow down in work zones?. Traffic Injury Prevention, 22(2), 177-181.

Debnath, A.K., Blackman, R., and Haworth, N. (2015) Common hazards and their mitigating measures in work zones: A qualitative study of worker perceptions. Safety Science, 72, 293-301.

Key words: Transportation Engineering, Work zone, Roadworks, Traffic simulation and Video analytics

Principal Supervisor:	A/Prof. Ashim Debnath
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Impact Theme	Building safe and secure communities
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Predicting and controlling corrosion of future renewal energy infrastructure by integrating corrosion monitoring and data analytics

Abstract: This project will develop and apply corrosion monitoring and closed-loop control technologies to enhance the sustainability and durability of future renewable energy infrastructures. The detection, monitoring, prediction and prevention of localised forms of corrosion and materials degradation is currently the most significant challenge. This project will further develop and apply corrosion probes and closed-loop corrosion control methods, developed by the Deakin University over the past decade, to protect complex renewable energy systems. This will be achieved by incorporating localised corrosion sensors/probes, data analytics, artificial intelligence, predictive modelling, and various anti-corrosion technologies and materials. This research will prepare technologies for the future renewable energy infrastructure and lead to important advances in lifetime prediction and in technological solutions for life extension of energy infrastructure.

References:

A. Lekidis, A. G. Anastasiadis, G. A. Vokas, Electricity infrastructure inspection using AI and edge platform-based UAVs, Energy Reports, (2022) 9, 1394-1411.

M. Wasim, M. B. Djukic, External corrosion of oil and gas pipelines: A review of failure mechanisms and predictive preventions, Journal of Natural Gas Science and Engineering, (2022) 100, 104467.

J. H. Simpers, K. Li, M. Greenwood, R. Black, J. Witt, M. Kozdras, X. Pang, O. Ozcan, Designing durable, sustainable, high-performance materials for clean energy infrastructure, materialstoday, (2023) 4, 101200.

M. Liu, W. Li, Prediction and analysis of corrosion rate of 3C steel using interpretable machine learning methods, Journal of Clean and Production, (2023)35, 106408.

S. Lin, F. Tang, J. Dang, X. Li, Automatic detection of steel rebar corrosion based on machine learning and light spectrum of fiber optic corrosion sensors, Optical Fiber Technology, (2023)79, 103379.

Key words: Infrastructure durability, Corrosion protection, Structural health monitoring and Renewable energy infrastructure

Principal Supervisor:	Prof Mike Yongjun Tan
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School	School of Engineering
Course	S915 – Doctor of Philosophy (Engineering)
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Impact Theme	Enabling a sustainable world
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship
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Hydrogen embrittlement and corrosion in hydrogen containing pipelines, development of inspection and monitoring techniques

Abstract: Pipelines provide an economical and effective potion for transporting hydrogen in large quantities over long/short distances in Australia. The potential damages caused by hydrogen embrittlement of steel pipeline in addition to the external pipeline corrosion can provoke sudden catastrophic failure of pipelines. Hydrogen penetrates in a metal microstructure and leads to a decrease in the ductility and toughness. The corrosion on the exterior surface of hydrogen pipelines can also result in significant damages over their lifetime. This project is concerned with providing strategies for mitigating these damage mechanisms through investigating pipeline steel performance under simulated pipeline corrosion and hydrogen embrittlement environments.

References:

N. Smith et al., Research Report on identifying the commercial, technical and regulatory issues for injecting renewable gas in Australian distribution gas networks, Prepared for Energy Networks Australia, Final Report, July 2017.

P. Cazenave et al., Hydrogen assisted cracking driven by cathodic protection operated at near −1200 mV CSE – an onshore natural gas pipeline failure, Journal of Pipeline Science and Engineering, 1 (2021) 100–121.

O. Barrera, et al., Understanding and mitigating hydrogen embrittlement of steels: a review of experimental, modelling and design progress from atomistic to continuum, Journal of Materials Science, 53(2018) 6251–6290.

X. Li et al., Materials science: Share corrosion data, Nature, 527 (2015) 441–442. 5. M.Y.J. Tan, Localized Corrosion in Complex Environments, Wiley, 2023, ISBN: 978-1-119-77860-8.

Key words: Infrastructural durability, Renewable energy infrastructure, Hydrogen embrittlement, Corrosion, Materials and Performance

Principal Supervisor:	Prof Mike Yongjun Tan
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Impact Theme	Enabling a sustainable world
Expression of Interest	Applicants are encouraged to contact the nominated principal supervisor to discuss project suitability and complete and Expression of Interest form
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Motion Control of Oscillatory Robots Subject to Payload Uncertainty

Abstract: Mounting base oscillation poses a significant challenge to the control of oscillatory base robotic manipulators (OBMs). The positioning accuracy of the system is severely affected by base oscillations. Many control strategies have been investigated, but most of them require measurement or prediction of base oscillations. This project focuses on a unique type of OBMs—the vehicle-mounted manipulator that operates completely within the non-inertial task space (base-fixed space). It is a great challenge to obtain information about its base oscillation in practical applications. In addition, the inherent payload uncertainty and actuator saturation make its control design more challenging. This project aims to develop novel control strategies that offer accurate positioning control for the OBMs.

References:

Guo, Y., Wang, Z., and Huynh, V. T. (2023) 'Bounded Positioning Control of Manipulators Subject to Base Oscillation and Payload Uncertainty', Machines Journal, 11(2), pp. 253-253

Key words: Oscillatory Based Manipulators, Robotic Arms, Stabilisation and Payload Uncertainty

Principal Supervisor:	Dr Van Thanh Huynh
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Impact Theme	Creating smarter technologies
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Scholarship	Applicants will need to complete an Expression of Interest and if successful apply for a Deakin University Postgraduate Research Scholarship
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Deep Reinforcement Learning for Autonomous Pollination

Abstract: A fundamental step towards an autonomous pollination process involves classifying flowers in line with their maturity, then apply pollen to the matured flowers. This project is concerned with the development of a novel deep reinforcement learning enabled both multi-classification and ensued pollination process to be done accurately and autonomously. The project will lead to development of novel algorithms that simultaneously identify correct flowers and guide actuators to the flowers for pollination.

References:

Bataduwaarachchi, S. D, Stewart, M., North, S., and Huynh, V. T. (2023) 'Towards autonomous cross-pollination: Portable multi-classification system for in situ growth monitoring of tomato flowers', Smart Agricultural Technology, 4, pp. 205-205

Key words: Autonomous pollination, Robot and Flower classification

Principal Supervisor:	Dr Van Thanh Huynh
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Removal of microplastics and nanoplastics in contaminated water using Biomass-derived adsorbents

Abstract: The widespread use of plastic products and improper disposal result in the accumulation of Microplastics (MPs) and nanoplastics (NPs) in the environment, which have been detected in various kinds of water including surface water, wastewater and seawater. These plastics are becoming a serious concern for the environment and are gaining significant attention due to the challenge in removing them. Among the serval removal technologies, adsorption is one of the advantageous technologies for water treatment due to its low-cost, simplicity, and efficiency. Biomass-derived biochar is another interesting material for adsorption applications because of its easy and scalable synthesis, high surface area, low cost, and environmental friendliness. Recently magnetic biochar (MBC) has also attracted attention because of its easy synthesis through loading of magnetic components into biochar. This study is mainly focusing on removing selected MPs and NPs using magnetic biochar. In real waters, size of MPs can vary significantly, this study can investigate whether magnetic biochar can remediate all size range of MPs and NPs. In addition, this study will also look at how co-existing contaminants affect the selected plastics removal.

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W.H. Chen, W. H, Hoang, A. T, et al. (2022) 'Biomass-derived biochar: From production to application in removing heavy metal-contaminated water', Process Safety and Environmental Protection, 160, 704–733.

J. Wang, J, Sun, C, et al. (2021) 'Adsorption and thermal degradation of microplastics from aqueous solutions by Mg/Zn modified magnetic biochars', Journal of Hazardous Materials, 419, 126486.

Key words: Microplastics, Nanoplastics, Adsorption, Magnetic biochar and Water source

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Impact Theme	Enabling a sustainable world
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Developing an efficient MBR-based hybrid treatment technology for the removal of trace organic contaminants from wastewater

Abstract: Trace organic contaminants (TrOCs) are a group of pollutants that are present at low concentrations in wastewater but can have a negative impact on the environment and human health. They are difficult to remove using conventional treatment methods because they are often soluble in water and not easily biodegradable. One approach is to develop an efficient MBR-based hybrid treatment technology by coating the membrane with a material that has a high affinity for TrOCs, which would allow the membrane to absorb the TrOCs and remove them from the water. Another approach is to develop hybrid MBR treatment technology, that could combine the advantages of MBR with another treatment technology, such as advanced oxidation process (AOP), that use strong oxidizing agents to degrade pollutants. By combining MBR with AOP, it is possible to achieve even higher removal rates of TrOCs. The aim of this study is to design and optimize the hybrid MBR treatment system by selecting a suitable AOP and membrane material with a coating that has a high affinity for TrOCs.

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Khan, A. N, et al. (2023) 'Emerging membrane technology and hybrid treatment systems for the removal of micropollutants from wastewater' Desalination, 565, 116873.

Zhang, S, et al. (2021) 'Removal of trace organic contaminants in municipal wastewater by anaerobic membrane bioreactor: Efficiencies, fates and impact factors' Journal of Water Process Engineering, 40, 101953.

Dhangar, K, Kumar, M, (2020) 'Tricks and tracks in removal of emerging contaminants from the wastewater through hybrid treatment systems: A review' Science of the Total Environment, 738,140320.

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Key words: Race organic contaminants, Hybrid systems, Membrane bioreactor and Advanced oxidation processes

Principal Supervisor:	Prof Bas Baskaran
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Nanocomposite solar photocatalytic degradation of emerging contaminants from landfill leachate

Abstract: Landfill leachate is a liquid that is formed when water percolates through a landfill and dissolves or suspends the pollutants in the waste. It contains a variety of organic and inorganic compounds, including emerging contaminants that can pose a health risk to humans and the environment. Among the various methods for degrading emerging contaminants from landfill leachate, the use of nanocomposite photocatalysts is a promising new technology. Solar photocatalytic degradation is a process that uses sunlight to activate a catalyst to break down pollutants. Nanocomposites, which have a high surface area to volume ratio, make them very effective catalysts for photocatalytic degradation. The aim of this study is to develop a nanocomposite solar photocatalyst that is effective in degrading emerging contaminants from landfill leachate and investigate the factors that affect the degradation efficiency of this process.

References:

Han, M, et al. (2020) 'Graphitic nitride-catalyzed advanced oxidation processes (AOPs) forlandfill leachate treatment: A mini review', Process Safety and Environmental Protection 139, 230–240.

Kanmani, S, Bharathi Dileepan, A,G, (2023) 'Treatment of landfill leachate using photocatalytic based advanced oxidation process – a critical review,' Journal of Environmental Management, 345,118794.

Evgenidou, E, et al. (2023), 'Photocatalytic degradation of the antiviral drug abacavir using titania-graphene oxide nanocomposites in landfill leachate,' Journal of Photochemistry & Photobiology, A: Chemistry, 439, 114628

Key words: Advanced oxidation processes, Leachate, Solar photocatalysis, Nanocomposite and Pollutant degradation

Principal Supervisor:	Prof Bas Baskaran
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Han, M, et al. (2020) 'Graphitic nitride-catalyzed advanced oxidation processes (AOPs) forlandfill leachate treatment: A mini review', Process Safety and Environmental Protection 139, 230–240.

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Key words: Advanced oxidation processes, Leachate, Solar photocatalysis, Nanocomposite and Pollutant degradation

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Climate resilient geo-infrastructure for extreme weather events

Abstract: As the global climate continue to change, the occurrence of extreme weather events such as floods, cyclones, storms etc. increases in every country. Damages to and failure of infrastructure caused by frequent catastrophic natural hazards cost human lives, deflate the economy and disturb day-to-day life. Geo-infrastructures are a vital part of infrastructure systems which is prone to natural hazards than other elements due to the continuous interaction between ground and the atmosphere. This research will investigate soil – atmosphere interaction under simulated extreme weather events and develop technique to mitigate the impact by modifying soil properties construction techniques. The research includes a series of laboratory experiments, analytical modelling and numerical analysis. The potential candidate must have a passion for experimental modelling and possess good analytical and mathematical skills.

References:

Costa S, Cherukuvada M, Islam T, Kodikara J (2023) 'Impact of climate change on shallow ground hydro-thermal properties. Bulletin of Engineering Geology and the Environment 82(16)

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Cui Y (2022) 'Soil-atmosphere interaction in earth structures', Journal of Rock Mechanics and Geotechnical Engineering. 14:35-49.

Key words: Climate change, Geo-infrastructure, Extreme weather and Soil-atmosphere interaction

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Sustainable soil bases with fibrous waste materials

Abstract: Expansive soils are clayey soil that exhibit excessive swelling and shrinkage in response to moisture change. About 20% of Australia's land cover consist of expansive soils which makes it challenging for construction. While traditional soil stabilisation methods have provided successful outcomes with cement and lime, it is important to focus on more sustainable materials. This research investigates the volumetric behaviour and mechanical strength of expansive soils stabilised with fibres derived from waste or recycled materials. Both organic and synthetic fibres will be tested with different soil types to develop a novel stabilising technique. The research includes a series of laboratory experiments, analytical modelling and numerical analysis. The potential candidate must have a passion for experimental modelling and possess good analytical and mathematical skills.

References:

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Key words: Expansive soils, Fibre, Recycled materials, Soil stabilisation and Reclaimed waste

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Harmonic Trade-offs in Electrolysers: Towards a Green Hydrogen Future in Australia

Abstract: Electrolysers, vital components in green hydrogen production, demand stable, consistent, and reliable power. Traditional power conversion from AC to DC via 9/12/24-pulse wave rectifiers introduces system harmonics, causing potential conflicts with the IEEE 519 standards on Total Harmonic Distortion (THD). This research aims to investigate and optimise the trade-offs between harmonics and cost in electrolyser power conversion, targeting a solution that negates the need for external filters and has no negative impact on the grid and/or microgrids. We'll explore various power conversion options including SCR Thyristors, IGBT Chopper, and Wide Bandgap Semiconductors, each presenting unique challenges in terms of complexity, efficiency, size, and controllability. Moreover, different electrolyser technologies like Alkaline, Proton Exchange Membrane (PEM), Anion Exchange Membrane (AEM), and Solid Oxide Electrolyser (SOE), with their diverse load profiles, further complexify the scenario. The objective is to conceptualize a solution that aligns with Australia's green hydrogen vision, assuring both environmental compliance and economic viability.

References:

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IEEE Standards Association. (2022) IEEE Standard for Harmonic Control in Electric Power Systems', IEEE Std 519-2022.

Key words: Electrolyser Harmonics; Green Hydrogen; Power Conversion; IEEE 519 Standards and Total Harmonic Distortion

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Ultrasonic levitation for dynamic analysis of pollutants dust particles

Abstract: In most air pollution cases, there are particles components contributing to the pollution of the air. Some of these pollutant particles such as dust, soots, smoke, or liquid drops could cause eye irritation, lung and throat irritation and breathing problems. For scientific study of the behaviour of these pollutant particles, systems for levitating and manipulating particles of interest in air in a non-destructive way or with minimal physical contact are needed. Ultrasonic levitation is a process of using ultrasonic waves to levitate particles. In this project, the aim is to better understand the motions and dynamics of air pollutant particles without the need for physical contact through ultrasound levitation.

References:

Link to reference

Key words: Ultrasonic, Levitation, Dynamic analysis and Particle manipulation

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The development of innovative strengthening solutions for highway bridges using Ultra-High-Performance Concrete and industrial waste.

Abstract: There is an urgent need for practical and durable rehabilitation solutions for deteriorated highway bridge decks. Deck deterioration is commonly caused by vehicle loading, cracking, delamination of cover concrete, and corrosion of internal reinforcement. Deteriorated bridge decks are naturally rehabilitated using overlays depending on the cause of deck deterioration, the available budget, and the desired service life of the rehabilitated structure. Common overlay materials include conventional concretes, high-performance concretes (HPCs), latex-modified concretes (LMCs), asphalt with waterproofing membranes, and polymer-based materials. UHPC offers several advantages, including enhanced material and durability properties, over conventional concretes and other cementitious materials, which led to it gaining the attention of the highway bridge design community. This project assesses the potential of UHPC made from cementitious composite materials and industrial by-products for overlay applications.

References:

Wibowo, H. and Sritharan, S. (2018), Use of Ultra-High-Performance Concrete for Bridge Deck Overlays, Tech Transfer Summary, Bridge Engineering Centre, Iowa State University.

Key words: Sustainable infrastructure, Ultra-high strength concrete, Highway bridge rehabilitation, Cementitious material and Recycled aggregate

Principal Supervisor:	Dr Riyadh Al-Ameri
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Performance assessment of Basalt Fibre Reinforced Polymer (BFRP) – Self-compacting Geopolymer Concrete (SCGC) framed structure under marine environment

Abstract: The Service life of infrastructure for durability in the aggressive marine environment requires a unique material to survive the corrosion perspective. In that context, BFRP bars, as a potential reinforcement replacement for conventional steel bars, have proven durable against corrosion. Conversely, its performance in the structural aspect against steel has not been thoroughly explored. The BFRP bars are made by pultrusion technology. The individual fibres are held together by a cured resin with hydrophobic surface morphology that has a compatibility issue in adhesion with a hydrophilic cementitious matrix. The proposed research addresses the suitability of environmentally durable Basalt Fibre fibre-reinforced polymer (BFRP) bars in concrete framed structures. This research will focus on an experimental investigation and a numerical study for beam-column connection subjected to repeated loading.

References:

Rahman, SK, and Al-Ameri, R (2023), Long-term performance of basalt fibre-reinforced marine geopolymer concrete in harsh environment, Magazine of Concrete Research, Link

Key words: Sustainable infrastructure, Ultra-high strength concrete, Highway bridge rehabilitation, Cementitious material and Recycled aggregate

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The behaviour of Composite low-carbon concrete slab with steel decking incorporating recycled aggregate

Abstract: Composite slab systems have become increasingly popular over the last decades because of the advantages of merging the two building materials, profiled steel sheets and concrete. The profiled composite slab's performance depends on the composite interaction at the concrete-steel interface in the longitudinal direction. Geopolymer concrete has emerged as a potential sustainable construction material over the last few years, which can substitute the concrete component in composite construction. The production of SCGC eliminates the need for elevated temperature for curing and high corrosive alkali-activator solutions as in traditional geopolymer concrete. Recent research at Deakin University has led to the development of a new GPC mix that is self-compacting and ambient cured, facilitating the commercial use of GPC in onsite construction. Improved behaviour of self-compacting geopolymer concrete has been obtained by incorporating treated recycled aggregate, which is unutilised Construction and Demolition waste, one-third of the national waste volume in Australia. This project is a continuation of the recent development at Deakin University.

References:

Nikmehr, B., Kafle, B. and Al-Ameri, R. (2023), "A review of the advanced treatment techniques for enriching the recycled concrete aggregates for recycled-based concrete: economic, environmental and technical analysis", Smart and Sustainable Built Environment. Link

Heweidak M, Kafle B, Al-Ameri R (2022), Shear-Bond Behaviour of Profiled Composite Slab Incorporated with Self-Compacted Geopolymer Concrete, Applied Sciences 12(17):1-20 Article number ARTN 8512 2022.

Key words: Sustainable infrastructure, Composite construction, Recycled aggregate, Construction and demolition waste and Low-carbon concrete

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Modelling of Hydrogen Combustion using Machine Learning

Abstract: Hydrogen is essential in transitioning from a fossil fuel-based economy to net-zero CO2 emissions. Realistic modelling of hydrogen flames is crucial for design of modern industrial applications. Due to the chaotic nature of turbulent flames creating flame models is often computationally prohibitive. We propose to use the modern machine learning methods, including deep learning, in modelling of hydrogen flames to avoid expensive direct flame simulations. We will use databases of hydrogen flames to train the algorithms such that low-fidelity simulations are sufficient to recreate the detailed flame dynamics. This project would enable the design of a new class of burners and facilitate the transition to low-carbon technologies.

References:

Chen S, Chue RSM, Yu SCM, Schluter JU, 2016, Spinning effects on a trapped vortex combustor, Journal of Propulsion and Power 32(5):1133-1145

Key words: Hydrogen, Computational Fluid Dynamics, Machine Learning, Modelling

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Simulation of Aerosol Spread of Respiratory Diseases

Abstract: The simulation of the transport of aerosol droplets created by coughing and sneezing, and sometimes just by talking, is important to understand transmission mechanisms of respiratory diseases. We are using Computational Fluid Dynamics together with a Lagrangian solver to gain insight to the processes of expulsion, evaporation and transport of aerosolised droplets.

References:

Schluter J, Zhao D, Sarkar A, Large eddy simulations of a turbulent mixing layer periodically excited with fundamental and third harmonic frequency, Chinese Journal of Aeronautics 1-9 2022

Key words: Computational Fluid Dynamics, Aerosols and Respiratory Diseases

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Additive manufacturing (AM) and its application in green hydrogen production

Abstract: Polymer electrolyte membrane water electrolysis (PEMWE) is the most promising and environmental-friendly method for highly pure hydrogen production when integrated into renewable energy sources. Porous transport layer (PTL) is one of the most important parts in PEMWE. A comprehensive understanding on PTL is essential to enhance the performance of PEMWE and reduce the cost. PTL's structural properties (pore size, porosity, pore gradient, thickness) and surface modifications have a great impact on its electrochemical performance (ohmic, mass transport, activation overpotential) and durability. Laser powder-bed fusion (LPBF) technique is low-cost additive manufacturing (AM) technology. By taking advantage of LPBF, it is possible to fabricate complicated three-dimensional designs of virtually any shape from a digital model into one single solid object faster, cheaper, and easier, especially for titanium components. The project includes 3 objectives: (1) Development of optimal LPBF processing window for the fabrication of porous titanium structure with controllable porosity. (2) Understanding of the mechanical/thermal/corrosion/electrical behaviours and surface characteristics of the LPBF-fabricated titanium porous structures. (3) Preliminary design and LPBF fabrication of an integrated titanium PTL/bipolar plate prototype for PEMWE.

References:

Nofar et al,(2022), “Foam 3D Printing of Thermoplastics: A Symbiosis of Additive Manufacturing and Foaming Technology”

Yang et al, (2015) “Fully printed and integrated electrolyzer cells with additive manufacturing for high-efficiency water splitting “

Ouyang and Xnu , (2022),”Carbon/Graphite Sheets/PTFE-Coated Porous Titanium as the Bipolar Plate by Hydrothermal Treatment”

Key words: Additive manufacturing, Green hydrogen and PEM

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Novel connections for steel-timber-concrete hybrid structural systems

Abstract: Hybrid structures made of steel, timber, concrete and other material types combine most suitable properties of various materials based on their merit and application. Every construction material offers unique set of mechanical properties that can be exploited in many ways in practical applications. However, use of various types of materials can be challenging when it comes to connecting structural elements made of different materials. Interactions between structural elements are always dictated by connections as they control the load transfer mechanism to ensure overall integrity of the structure. This project will investigate the current practices in designing such hybrid structures and will identify underlying gaps as there are very few design guidelines available for such complex applications. Most design problems are solved on ad-hoc basis and hence are overdesigned. Fundamental behaviour of connections between steel-timber and concrete-timber will be evaluated using experimental techniques. Those test evidence will be sued to develop FE models to conduct comprehensive parametric analysis. Obtained results will ultimately be used to proposed analytical models and design guidance to promote use of hybrid structural systems in construction.

References:

Moritani FY, Martins CEJ, Dias AMPG. A literature review on cold-formed steel-timber composite structures. BioRes 2021;16:8489–508. Link

Moritani; Loss C, Piazza M, Zandonini R. Connections for steel–timber hybrid prefabricated buildings. Part II: Innovative modular structures. Construction and Building Materials 2016;122:796–808. Link

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Li Z, He M, Lam F, Li M, Ma R, Ma Z. Finite element modeling and parametric analysis of timber-steel hybrid structures. Struct Design Tall Spec Build 2014;23:1045–63. Link

Key words: Hybrid structure, Steel-timber connection, Concrete-timber connection and FE analysis

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